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FLAVOR

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FLAVOR

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ing agents and methods of using them, it is not a recipe or formula compendium and does not deal with the subject matter now covered adequately by a legion of excellent cookbooks.

An extensive but selected bibliography classified by subjects to correspond to the chapters of the book is included for the convenience of those who wish to pursue and advance particular phases of the work on flavor.

The author has drawn on his experience particularly as a consultant on the chemistry of flavor, but he has also made use of the findings and writings of workers in related fields in order to give a broad treatment of the subject. He gratefully acknowledges the assistance of members of the staff of Arthur D. Little, Inc., especially Dr. M. G. Gray on matters of anatomy and physiology, and Mr. Raymond Stevens for his general interest in gastronomy and his constant encouragement.

E. C. CROCKER.

CAMBRIDGE, MASS.,
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Introduction

FLAVOR influences the acceptability of nearly everything that passes the lips, whether it be food, beverage, tobacco, medicine, or tooth paste. Whatever is pleasant is preferred over that which is less pleasant and is sure to be used more willingly and freely. Commercially this may mean the greater sale of one man's product over his competitor's for the same human need, although the price for the product is the same and the advertising appeal is equal. Nutritionally flavor is of great importance, especially to those of poor or capricious appetite, who may not consume enough food unless the flavor is especially attractive.

The flavor of food was probably appreciated for a long time before much could be done about it. Whether the art of seasoning actually preceded or followed the discovery of cooking, the use of salt, at least, was more urgently called for on cooked foods than it was on uncooked grains, nuts, fruits, raw meat, and fish. One may picture the cooks of early civilization as trying practically everything within reach to enhance the taste of roasted meats, stews, and parched grains. The problem of making food eatable when it was no longer fresh was certainly a serious one at times. Only a few centuries ago, pepper literally was worth its weight in gold for seasoning the unrefrigerated food of the world. Cinnamon, cloves, and other spices were highly enough esteemed to justify a regular camel-borne traffic, with all its cost and hazard, over thousands of miles across Asia. Today not only are the time-tested flavoring substances of all the earth available for flavoring, but also new or selectively improved natural materials and a host of synthetic substances not even imagined by early man. With these condiments one may season the wealth of food

products of the present day. Foods themselves are constantly being improved in quality and flavor and are being delivered to the consumer in ever better condition; as a result, there is less need for added seasoning. Good flavor in food is automatic insurance that people will eat enough not only to maintain their health but also, if the supply is sufficient, to reach that desirable but still somewhat nebulous and disputed point of "optimum nutrition."

Flavor is that quality of food which makes it register favorably or otherwise on the senses. Reduced to lowest terms flavoring agents are chemical substances which are able to impress themselves on the senses of taste, smell, and feeling by way of food and drink. These chemicals are of many types and origins; some occur naturally in foods; some develop within food while it is being cooked or otherwise processed; and others are added substances of natural or artificial origin. Some flavoring agents such as salt, sugar, or sodium glutamate are pure in form, while many others, such as the spices, are complex mixtures of organic chemicals that may be alcohols, aldehydes, ketones, esters, hydrocarbons, or phenols, to name some of the most important chemical classes. Nearly all of the flavoring chemicals that have been identified in foods have been duplicated synthetically, and in some instances these synthetics have been used in flavoring.

Some foodstuffs, notably coffee and chocolate, contain within the raw product chemicals that develop new and strong flavors during a roasting process. Indeed, most foods have distinctive flavor developed to some extent on cooking. A pot roast of beef, for example, through pyrogenesis gains much additional flavor in the searing operation at high temperature that precedes the gentle cooking that tenderizes the meat.

In the aging of butter and cheese, bacterial cultures develop new flavors; and in the aging of liquors, chemical reactions and the extraction of flavor from the wooden container combine to build up the final flavor.

INTRODUCTION

The chemical aspects of flavor must be given consideration with respect to condiments or added flavoring agents as well as to the food that carries them. Attention must also be given to the container in which it is kept, to oxygen, heat, and light, especially when the food is to be preserved for a long period. Such chemical consideration will not necessarily favor the use of synthetic or imitation flavors, or even of condiments, but primarily will be guardian over the natural flavors, as far as possible, and their retention in the final product.

The action of flavors on the sense receptors, located chiefly in the mouth and nose, is, in a broad sense, to set up electrical impulses which travel over the sensory nerves to the brain, where the impressions are noted. These electrical impulses are understood as yet only in a general way, while the nature and actions of the receptors that set them in motion or the receivers in the brain that note them are understood scarcely at all. The paucity of information regarding the production and transmission of sensations due to flavor need not, however, prevent analysis of the sensations produced and the development of a practical psychology concerning these sensations. Sensation analysis, considered in much detail in the following chapters, first from a theoretical and then from a practical standpoint, provides a unifying basis for a mass of otherwise heterogeneous matter.

Chapter 1

The Elements of Flavor

FLAVOR is the complex of sensations through which the presence and identity of foods and beverages in the mouth are determined. In ordinary uncritical language, one "tastes" flavor, but this expression implies the complete perception of flavor by the receptors of true taste located on the tongue, though, actually, the perception of most flavors involves several senses. Any technical consideration of flavor must take this fact into account.

Tongue taste encompasses very well the flavors of such substances as salt, citric acid, sugar, and quinine but misses widely the flavors of many others, including fruits, coffee, and butter, which depend more upon odor than they do upon true taste. Odor can be detected effectively from within the mouth quite as well as through sniffing by the nose, for there is a convenient and effective back entry from the mouth to the smelling area in the head by way of the throat. Some of the scented air is pumped up to the smelling area each time one swallows. The warmth and moisture of the mouth make odor perception even more delicate and discriminating than it is through ordinary sniffing. Moreover, less effort is needed to note odors by this back route, since a vigorous lifting of air is required for good smelling by the nose.

But flavor perception involves more than odor and taste. They fail, for instance, to account for the biting or the burning part of the flavors of mustard, cloves, pepper, and other spices or for the coolness of peppermint flavor. For the

detection of bite or burn, coolness, and such sensations as the tickle of the bubbles of soda water, the receptors of the sense of touch are utilized. Thus no less than three distinct senses may be engaged in the perception of any particular flavor: the sense of tongue taste, the sense of smell, and the sense of feeling. Although these senses are distinct and report through three separate sets of nerves, they register simultaneously in the brain. Careful observation consequently may be needed to distinguish which are present in any given flavor.

If the nose is held, obviously the possibility of smelling from the front is shut off, but there is also interference with smelling by way of the throat. It is most enlightening to apply various tasty substances to the tongue while the nasal passage is restricted either by pinching or by the use of plugs. Raw onions, for example, then taste sweet only, and so does cinnamon. A slice of apple tastes sweet and sour, and the outer oily part of abraded lemon skin has only a bitter taste. In these illustrations the sensations noted are chiefly those of true tongue taste, because smelling has been eliminated. With the sense of smell shut off, black, white, and red pepper, which have little true taste, can be detected by their strong burn. Oil of peppermint, which tastes weakly bitter, feels cool, first on the tongue, then all around the inside of the mouth, and, if some is swallowed, finally down into the chest. In these last instances, where smelling is blocked and no true taste interferes, the flavor sensations noted are mostly those of feeling.

By sniffing some of the aroma it is easy to detect odor apart from taste, but it is not always easy to separate odor from feeling. Most mild odors, including odors of the majority of flowers, fruits, and perfumes, are detected by smell sensations only. However, any odor possessing a strong sting or pungency will stimulate the sense of touch. In general, if odors are greatly weakened, only the sense of smell is stimulated. Examples are numerous where the strong element of pungency appears as a stimulation of the

pain receptors of the sense of touch, which is especially acute in the nose. Pure menthol has a relatively weak odor; nevertheless it is able to excite the coolness nerves of the sense of touch within the nose or mouth. This chemical, undiluted or as an important ingredient in oil of peppermint, can cause a feeling of coolness when applied almost anywhere on the body. Many mouth-burning substances exist, such as alcohol and the oleoresins of ginger and red pepper, which also are able to register warmth through the nerves of various parts of the skin of the body. Roots of many varieties of plants of the arum family, including the Indian turnip (jack-in-the-pulpit), contain minute needle-like crystals of calcium oxalate which can penetrate the mucous membrane and cause painful stinging in the mouth. These roots are without flavor other than this painful sensation.

The sense of smell frequently requires only millionths of a milligram of matter for powerful excitation, whereas the sense of taste may require as much as a hundredth of a milligram even for the detection of such powerful stimuli as quinine or saccharin, and several milligrams for salt or sugar. Vapors exist, however, such as that of sulfur dioxide, which in great dilution may be detected by the sense of taste more specifically and perhaps more delicately than is possible by the sense of smell. This fact is well shown by exposing the tongue in an atmosphere containing such a small quantity of sulfur dioxide that it cannot be smelled. This gas will dissolve in the saliva, and the concentration will build up until it may register as a sour taste.

The Tongue-taste Element of Flavor

The sense of tongue taste (true taste) operates through curious structures called taste buds, located principally on the tongue, but also to some extent in adjacent parts of the mouth. These buds and their function are described in detail in Chap. 2 on the Physiology of Flavor Perception. Whatever reaches these receptors to stimulate them must

be in watery solution. In general, tasting occurs when sapid solutions are presented to the top of the tongue. A few exceptions are known, however; for example, the intensely bitter substance, sodium dehydrocholate, may be tasted on the tongue a few seconds after some of it has been injected into the blood stream at some distant part on the body, such as an arm or leg. Thus, one can virtually taste his own blood, flavored intensely bitter, from the "lower side" of the taste buds. The author has observed the taste of vitamin B_4 (thiamine) about 10 sec. after a 10-mg. dose was injected intravenously into his arm. The peanutlike taste was noticed intermittently for several minutes.

It has become quite orthodox to speak of four components of taste: *sweet, sour, salty,* and *bitter.* Throughout this book these subsenses will be referred to in this popular way for the sake of convenience. However, there is some reason to question the complete technical equivalence of the elements of tongue sensation. Until very recently, most physiologists considered these subsenses as all of equal status and similar nature. The experimental psychologist Samuel Renshaw, however, has noted that sour and salty behave differently, with respect to speed of perception, at high and low temperatures from the other elements sweet and bitter —enough different in his opinion to place them in a separate category. The influence of temperature on the perception of sourness is well illustrated by a candymaker's complaint that sour-flavored candies, such as lemon drops, tasted insipidly sweet, like so much plain sugar, at the high temperatures frequently encountered in deserts and in the tropics. Also, tea with lemon does not taste sour when sipped hot; the sourness develops only as the tea cools down. If food is to be salted skillfully, the tasting should be done when the food is neither very hot nor very cold. Most accurate tasting is done with solutions at body temperature or slightly below.

From a physicochemical standpoint also, there is a distinction between the pair sweet-bitter and the pair sour-

salty in that the stimuli for the latter are always chemical ions, electrically charged particles, whereas stimuli for the former may or may not be ionic.

There are many nonionic stimuli for sweetness, including most of the sugars, the glucoside glycyrrhizin of licorice, some aldehydes (cinnamic, for example), certain nitro-compounds, some aliphatic chlorides (such as chloroform), saccharin (*o*-benzoic sulfimide), dulcin (*p*-phenetyl urea) and the antioxime of *l*-perilla aldehyde. The last three substances are hundreds of times sweeter than sucrose, weight for weight. The ionic stimuli for sweetness include lead and notably beryllium salts (the old name of beryllium was glucinum, the "sweet element"). The threshold amount of sucrose, the quantity that can just be detected as "sweet," is about 7 mg. Sugar solutions of 0.25 per cent strength in teaspoonful (4 cc.) quantities can be detected as sweet by most people.

Many nonionic stimuli exist for bitterness, such as the alkaloids as a class, exemplified by caffeine, strychnine, brucine and quinine; the glucosides, including the naringin of grapefruit; polynitro-compounds including picric acid; and lastly, substances such as tannin and sucrose octa-acetate. Most bitter substances are but slightly soluble in water, and even when they are in solution, bitterness detection is relatively slow. On the other hand, this sensation once stimulated may last for a considerable period. Bitter-tasting ions include those of silver, ferric iron, cesium, rubidium, and iodine. The threshold quantity, that amount which is just detectably bitter, of quinine hydrochloride is frequently about 0.016 mg., and of caffeine about 0.040 mg. There is great variability among people in detection of bitterness.

Salty taste is always due to ions. It reaches the pinnacle of strength and purity when the cations lithium or sodium are present simultaneously with the anions fluoride or chloride. (Caution: all fluorides are poisonous.) Other conspicuously salty cations (with some bitterness) include

potassium, magnesium, and ammonium. Anions associated with saltiness include the halides as a class (although iodide is predominantly bitter), the lower members of the acetic series of acids, the carbonates, nitrates, and sulfates. The threshold quantity of sodium chloride for a detectable salty taste, carefully determined, is about 1.5 mg., but some 10 to 20 mg. is needed for easy observation. Salt solutions in distilled water tasted in teaspoonful amounts are not definitely "salty" at a concentration of much less than 0.5 per cent, although the threshold of taste is much lower.

Sour taste is caused only by hydrogen ions. Only acids, acid salts, lactones, phenols, or other substances which generate hydrogen ions in contact with water give the sour taste. All acids have about the same amount of sourness of taste for the same molal strength and degree of ionization. Solutions of the weakly ionized boric and carbonic acids, for example, taste barely sour, whereas those of acetic and most other moderately ionized organic acids are emphatically sour. Solutions of the strongly ionized mineral acids not only taste extremely sour but, in addition, stimulate the feeling of astringency and "set the teeth on edge." The threshold amount of tartaric and similar acids that may be detected under favorable conditions is about 0.2 mg. Teaspoonful (4 cc.) quantities of 0.006 per cent citric acid are just noticeably sour to most people, while the same quantities of 0.010 per cent citric acid are plainly sour.

The Sense of Smell

The odor-detection area is located high in the nasal cavity, immediately below the eyes. It consists of a much convoluted yellow-colored zone, somewhat larger than a postage stamp, with a "brush" of tiny olfactory hairs extending beyond the layer of mucus, awaiting stimulation. (See Chap. 2, on the Physiology of Flavor Perception.) In ways not yet understood, molecules of certain chemicals scattered among those of inhaled air are able to stimulate

smell receptors so that the presence of the chemicals is made known, frequently with such definiteness that they may be identified by those familiar with them from the odors alone.

Odor Classification

Not only is the mechanism of smelling by which odors are detected largely unknown, but there is also uncertainty even about the number of kinds of different odors that exist and what these kinds may be. If we draw a parallel with the senses of sight, taste, and feeling, and assume economy on the part of nature, it seems reasonable to believe that there are relatively only a few kinds of odor-responsive receptors to register the whole gamut of smell sensations, rather than a multitude of types any one of which might be stimulated but rarely. Several attempts to classify odors into groups and a few attempts to analyze odor sensations into components have been made. Examples of each are given below. Odors are perceived subjectively as impressions or sensations, and it is difficult to treat these sensations in a strictly objective, cause-to-effect manner. Classifications of odors have been made, as accurately as possible, by comparing odors, grouping and analyzing sensations, and thereby building up odors from the assumed components. This procedure of analysis and synthesis was repeated until conclusions were reached.

An elaborate and inclusive classification of odors, which contains nine classes of odors, with numerous subclasses, is shown below. The classification makes no pretense of being analytical.

Zwaardemaker's Classification of Odor Types

(Translation of Bogert)

1. Ethereal or fruity: characteristic in general of fruits and due in most cases to the presence of various esters; includes also beeswax and certain ethers, aldehydes, and ketones

2. Aromatic:
   a. Camphoraceous: borneol, camphor, eucalyptole
   b. Spicy: eugenol, ginger, pepper, cinnamon, cassia, mace
   c. Anise-lavender: anethole, lavender, menthol, thymol, safrole, peppermint
   d. Lemon-rose: geraniol, citral, linalyl acetate, sandalwood
   e. Amygdalin: benzaldehyde, oil of bitter almonds, nitrobenzene, prussic acid, salicylaldehyde
3. Fragrant or balsamic:
   a. Floral: jasmine, ilang-ilang, orange blossoms, lilac, terpineol, lily of the valley
   b. Lily: lily, tuberose, narcissus, hyacinth, orris, violet, ionone, mignonette
   c. Balsamic: vanillin, piperonal, coumarin, balsams of Peru and Tolú
4. Ambrosial: musk and amber. This odor is present in the flesh, blood, and excreta (referable to the bile) of certain animals
5. Alliaceous or garlic: onion, garlic, and many compounds of sulfur, selenium, tellurium, and arsenic:
   a. Alliaceous: hydrides of sulfur, selenium, and tellurium, mercaptans, organic sulfides, thioacetone, asafetida
   b. Cacodyl fish odors: hydrides of phosphorus and arsenic, cacodyl compounds, trimethylamine
   c. Bromine odors: bromine, chlorine, quinone
6. Empyreumatic or burnt: as in tar, baked bread, roasted coffee, tobacco, benzene, naphthalene, phenol, and products of the dry distillation of wood
7. Hircine or goaty: due in the case of this animal to the caproic and caprylic esters contained in the sweat, and typified also by perspiration and cheese
8. Repulsive: such as are given off by many of the narcotic plants and by acanthus
9. Nauseating or fetid: such as are given off by products of putrefaction (feces, etc.) and by certain plants

Henning sought to analyze the sensations produced by all odors into a limited number of fundamental sensations. He concluded that there were six fundamental sensations and that all actual odors stimulate combinations of one, two, three, or sometimes four of these. He devised a model, for study purposes, in the shape of a triangular prism. One of the six fundamental sensations was represented by each point; combinations of two sensations were represented on

the edges, and combinations of three or four on the surfaces. Henning's fundamental odor sensations are listed below.

Henning's Six Fundamental Odor Sensations

1. Spicy: conspicuous in cloves, cinnamon, nutmeg, etc.
2. Flowery: conspicuous in heliotrope, jasmine, etc.
3. Fruity: conspicuous in apple, orange oil, vinegar, etc.
4. Resinous: conspicuous in coniferous oils and turpentine
5. Foul: conspicuous in hydrogen sulfide and products of decay
6. Burnt: conspicuous in tarry and scorched substances

The writer, in collaboration with L. F. Henderson, took Henning's six fundamental odor sensations as a starting point and attempted by covering the ground anew to break down all odor sensations into the same or other elementary sensations. The conclusions reached were that several of Henning's "fundamentals" were really composite, that some odors were not characterized, and that only four kinds of fundamental sensations are essential for the comprehension of all odors. These are indicated below.

The Four Fundamental Odor Sensations of Crocker and Henderson

1. Fragrant, or sweet (like Henning's "flowery")
2. Acid or sour (not previously characterized)
3. Burnt or empyreumatic (like the "burnt" of Henning and also of Zwaardemaker)
4. Caprylic, goaty, or oenanthic (like the "hircine" of Zwaardemaker)

When the sensations are strong, this arrangement places them in the order of their interest to most people. *Fragrant* is most liked, *acid* next, *burnt* is slightly disliked, and *caprylic* is much disliked.

It was observed that nearly every odor stimulates all four kinds of receptors and causes sensations of various degrees of relative intensity. It became desirable, therefore, in order to express the individuality of an odor to include quantitative values for each of the four sensation elements. This was done by assigning for each component intensity

digits of 0 to 8 for the nine recognizable degrees of sensation intensity. With most odors, convenient "internal standards" exist in the form of the other three components. These may be contrasted, one against the other, for intensity of sensation in appraising the strength of each component in turn. This is analogous to what is done, though by

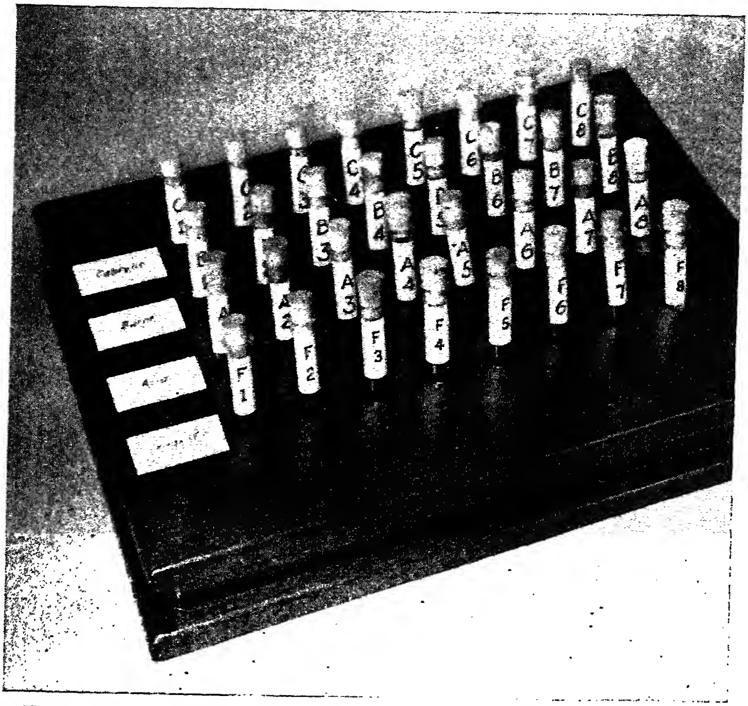


FIG. 1.—Block of odor standards. (*Laboratories of Arthur D. Little, Inc.*)

other means, in quantitative spectrum analysis, where the strengths of particular lines of the element that is being determined are compared with near-by lines caused by added known amounts of other elements.

It is possible with numerical values to represent any odor by a four-digit number, for example, 3803 for acetic acid. The first digit, 3, describes this odor as moderately *fragrant*, 3 on the scale of a possible 8. Next, the *acid*

value is the full 8, which means it is as sour as any known odor. The *burnt* value is called 0, and the *caprylic*, 3. Likewise, the odor of toluene is 2424, α-terpineol is 6323, and the damask rose, 6523. For most odors, each fundamental is conveniently evaluated in intensity by comparing it with the graduated values in an external set of chemicals or odor "standards," such as that given in Table 1.

The standards selected are relatively harmless substances that are safe to smell repeatedly and that remain constant in odor over a long period of time. Each standard necessarily has values of all four components, but is of interest chiefly for the one indicated. Methyl salicylate, for example, is rated as 8 in *fragrance,* meaning that it is as strong in that element of odor as any known material. Careful distinction must be made between the terms "fragrant" and "pleasant," for this 8 standard does not compare in pleasantness with many floral odors that may have values of only 6 or 7, but which have more favorable values of the other components and, what is more important, elicit more pleasing memories. Moreover, "fragrant" in this analytical sense is independent of the *volume* of scent released.

Odor Mixtures

The sense of smell, possibly even more than the sense of hearing, is analytical and discriminating in the extreme. It is doubtful if long practice in smelling can improve the delicacy of odor detection. It does, however, greatly improve one's capacity for concentrating upon and objectifying the many odors often present in a mixture, for identifying each, and for analyzing each one into its sensation components. A mixture to the trained nose is always composé. There is awareness that many separate odors are present. Only rarely will odors add together so perfectly that the combination will seem to be a single odor and the analytical powers be unable to detect its

complexity. An odor mixture is roughly comparable with a chord in music; one detects it as complex but is or is not satisfied with the resultant degree of harmony. In a pleasing odor, whether it be the natural aroma of a mango or McIntosh apple or the synthetic creation of a perfumer, the separate notes are detected over a background or accompaniment of "fixative," which, while it does not

Table 1.—Odor Standards (Revised, 1944)

	Fragrant		*Acid*
1112	*n*-Butyl phthalate	7122	Vanillin
2424	Toluene	7213	Cinnamic acid
3336	α-Chlornaphthalene	5335	Resorcinol dimethyl ether
4344	α-Naphthyl methyl ether	2424	Toluene[1]
5645	Cymene	5523	Isobutyl phenylacetate
6645	Citral	5626	Methyl phenylacetate
7343	Safrole	5726	Cineole
8453	Methyl salicylate	3803	Acetic acid (20% solution)
	Burnt		*Caprylic*
5414	Ethyl alcohol	——	No suitable standard found
7423	Phenylethyl alcohol	7122	Vanillin
5335	Resorcinol dimethyl ether	7343	Safrole
4344	α-Naphthyl methyl ether	5624	Phenylacetic acid
4355	Veratrole	5645	Cymene
6665	Thujone	3336	α-Chlornaphthalene
4376	Paracresyl acetate	2577	Anisole
7584	Guaiacol	3518	2,7-Dimethyl octane

[1] A single substance may serve for several standards. The substances included in this table have been chosen because they are reasonably reproducible in odor from lot to lot, safe to breathe in the quantities required for comparisons, readily available from chemical sources, and reasonably stable against changes in use or on standing.

actually fix the odor in the sense of retarding its evaporation, does tie all the notes present into an acceptable odor chord. One cannot raise the pitch of a note in music by adding to it a higher note. The ear hears two notes. The same is true in odor; one cannot add fragrance or take away caprylic, and so forth. When combinations are made to modify any single odor, the nose detects admixture and, perceiving it to be such, may be satisfied with it.

The Sense of Touch in Flavor

The sense of touch is involved in flavor in several ways. The temperature and texture of food or drink are extrinsic factors that both in themselves and in their effect upon the perception of taste and smell may have a marked influence upon flavor. There are also intrinsic stimulatory factors in foods, which act independently of actual temperature and texture, yet which cause them to affect the receptors of the senses of warmth, coolness, and touch in a physico-chemical way.

Effects of Temperature

A sip of hot soup may cause so much stimulation of the pain nerves that no flavor at all can be perceived. Drinks that are too cold likewise cause a degree of discomfort, which may prevent a detection of the finer shadings of flavor. On the other hand, drinks such as coffee must be taken at about 140°F. in order to give the accustomed refreshment, a fact which indicates that warmth is sometimes a virtual flavor element.

Temperatures well within the pain extremes also influence the perception of both smell and taste. Ice cream may seem almost flavorless if eaten rapidly, whereas if each small spoonful is allowed to warm up a little in the mouth before being swallowed, a flood of aroma will be released, at this higher temperature, to course upward through the throat to the nose, to register as the "taste" of vanilla, strawberry, raspberry, or chocolate. By an entirely different mechanism, temperature acts upon the sense of true taste in the mouth. Hot acidulated drinks, such as tea with lemon, do not taste sour as they are sipped, but do so a moment later when they have cooled down a bit and the flavor has widened to encompass sourness. The explanation is that the sourness receptors do not operate at temperatures much above 100°F. The same is true for saltiness; consequently soup must be allowed to cool to body temperature or below before it can be judged for salt-

iness. Temperature has a less noticeable influence on the sweet and bitter taste components.

Tactual Considerations

In the preparation of chocolate, and also of peanut butter, the roasted beans are comminuted to extreme fineness, and then extra fat from the same source, plain or hydrogenated, is frequently added. Unless the grinding is fine enough, the product will be gritty, and unless the correct amount of fatty lubricant is added, the product will feel "dry" in the mouth. The textural element (contact sense) is important in determining the quality of vegetables and meats and the degree of processing most favorable to many foods. Corn bread might not be identified as such if the corn meal were ground to flour. Pea soup that has a coarse, though soft, texture may actually be preferred over a soup without coarse particles. Lin Yutang wrote that the Chinese "eat food for its *texture*, for the elastic or crisp effect it has on the teeth, as well as for fragrance, flavor and color." Texture properly is part of flavor, if only because an unaccustomed texture places the senses of taste and smell under a handicap.

Texture also influences flavor in another way; it partially controls the quantity of sapid matter that can reach the taste buds in a given time. A thin liquid of strong taste will seem much weaker in flavor if a thickening amount of algin, gum tragacanth, flaxseed, or other source of mucilaginous matter is added to it. This weakening of taste is probably entirely mechanical; the viscosity of the fluid interferes with diffusion of the soluble substance to the sensory receptors. A buttermaker recently stated that the flavor of a given churn of butter can be influenced markedly by the way the butter is "finished"; if the texture is left "open," the butter will be relatively strong-tasting, whereas if it is "closed" to the point of waxiness, or even to greasiness, the taste will be relatively mild. Certain wetting agents can also influence flavor, the extreme case being a

water-in-oil agent, which if present in a fatty mass may make for mere oily feeling apart from true taste. In this instance the particles of sapid solution are isolated as the dispersed phase of an emulsion.

Physicochemical Elements of Flavor

There are elements in many flavors that, independent of temperature and texture, cause these flavors to register in terms of feeling. This result may come from a stimulation of the pain sense, known in the nose as *pungency* and in the mouth as *bite*, from excitation of the warmth or coolness nerves or from tactual stimulation.

An important factor in controlling pungency is the concentration of the aroma. When odors are faint, they rarely are pungent; when they are strong, pungency is frequent and perhaps general. There are many odors, however, of which pungency is an important part of their character at all usual concentrations. This feature is outstanding in the odors of onions, garlic, and horse-radish, spices in general, and in vinegar. Pungent flavor odors range from the flowery pungency of cloves and allspice through the herbaceous pungencies of sage and the other mints to the combination of the rank and pleasant pungencies of mustard, cabbage, nasturtium seeds, and turnips. Nearly all substances with pungent vapors also have a biting taste, which indicates stimulation of the pain sense within the mouth.

There are some substances, including red, white, and black pepper, and ginger, which have powerful burning tastes caused by nonvolatile components, independent of the relatively mild aromas. A convenient way to determine whether the pungent or burning substance is volatile or nonvolatile is to boil a small quantity with water until about half of the water has been boiled away. By that time, if the stimulating substance is volatile, it would have vanished along with the odor; but if nonvolatile, it would be in the dregs, as with black or white pepper; or in the

water, as with red pepper, and taste as strong as ever, or stronger. The hot "peppery" taste appears to be caused by direct chemical stimulation of the receptors of warmth. When alcohol and certain other so-called "hot" substances are tasted, the sensations can also be accounted for by assuming stimulation of the warmth element. The internal "genial" glow and tingle produced when these substances are swallowed may, however, be pain, in part, accompanied by local irritation, noted but vaguely because of the scarcity of receptors in the affected area.

The substance *l*-menthol is apparently unique in being able to produce a feeling of coolness in the mouth when tasted or in the nose when the aroma is sniffed. Even the other isomeric menthols lack this property. Menthol can produce the feeling of coolness when applied to the forehead or on the back of the hand, on intact skin, although the time required is longer and the quantity greater in these instances than when it is sniffed or tasted. The large content of menthol in oil of peppermint accounts for its cool flavor. The feeling of coolness is in no wise due to lowering of temperature by evaporation. While the net effect of *l*-menthol is to stimulate the coolness receptors to register as "cool," apparently it does not stimulate them directly, but rather sensitizes them so that on even slight application of actual coolness the cool impression is strong. A crystal of menthol may be held on the tongue, for example. As long as the mouth is shut, there is no feeling of coolness, but when a little air is drawn in, this air seems to have come from Greenland.

There is a chemical type of tactual element in some flavors. Alkaline substances, such as aromatic spirits of ammonia, bicarbonate of soda, soap, milk of magnesia, some very ripe cantaloupe melons, and certain sea foods including clams, crabs, and shrimp have a so-called "alkaline" taste which is probably mostly a feeling, that feeling which accompanies chemical attack on the delicate mucous membrane of the mouth. Fortunately, the membrane is

soon replaced if only slightly injured. The juice of raw pineapple, or the sap of green papaya, although not alkaline but rich in enzymes, also has some desquamatative action, which results in actual sore areas if contact is long maintained.

A notable tactile effect of flavor is that characteristic of sodium glutamate. This mild-flavored substance produces a sense of satisfaction within the mouth that may last for as long as an hour. While this feeling is not yet understood, its evaluation by a Chinese restaurateur is revealing: "Glutamate makes a vegetable diet tolerable."

Chapter 2

The Physiology of Flavor Perception

THE organs of taste and smell are similar to the other sensory mechanisms of the body in the manner in which they deliver sensations to the nervous system. Connected with the specific end organs are nerve fibers which carry impulses to the particular centers of the brain that are concerned with integration of appropriate responses. No matter how much the reactions of individuals to taste or smell may vary in degree, the sensory mechanism is the same in all persons, *viz.*, (*a*) a peripheral end organ or receptor, (*b*) a sensory path along the nerve or nerves, and (*c*) a center in the cerebral cortex which analyzes and interprets the sensation.

Taste Buds

Taste in the strict sense of the word is the sensation perceived on stimulation of the taste buds, located chiefly on the tongue. In man, taste buds are confined to the buccal cavity; in many other species the distribution is wider. Certain fishes, for example, have taste buds scattered over the entire body surface, in addition to those in and near the buccal cavity. For these species, the threshold of stimulation is lower than it is in man, especially for the end organs in the gill region. In horn pout or catfish, carp, and suckers, taste buds are also prominent on the barblets. Taste is an important sense used by fish in the selection of food.

In man, the upper surface of the tongue is the chief site of taste receptors, although a few taste buds are located on the anterior and posterior surfaces of the epiglottis, the inner surface of the arytenoid process of the larynx, the soft palate above the uvula, the anterior pillars of the

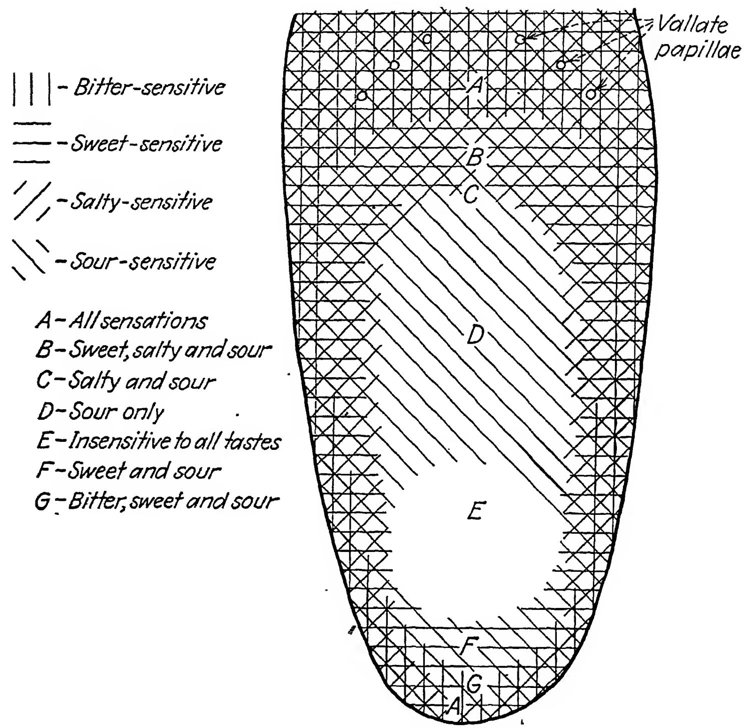


FIG. 2.—Approximate location of areas on the tongue sensitive to each of the four tastes.

fauces, and the posterior wall of the fauces. There are no taste buds on the floor of the mouth or on the gums. In fetal life and in childhood there is a greater abundance of taste receptors than in maturity. In infants, taste buds are to be found in all parts of the oral cavity. As a child grows, the most sensitive area shifts from the tip of the tongue to a position at the back of the tongue, near the

circumvallate papillae. Acuity of taste is believed to be an inherited, simple recessive character.

Taste buds are modified epithelial cells about which the dendrites of nerve cells arborize. In turn, they connect with the central nervous system by means of branches of the seventh, ninth, and tenth cranial nerves. There is no single specific gustatory or taste nerve, corresponding to the first cranial or olfactory nerve which is specific for smelling. Those fibers that lead to taste buds in the two-thirds of the tongue nearest the lips are branches of the chorda tympani and lead eventually by way of the seventh or facial nerve to the geniculate ganglion in the cerebral cortex. The taste buds of the third of the tongue at the back of the mouth are innervated by fibers of the ninth cranial or glossopharyngeal nerve. The taste buds in all other portions of the buccal cavity are innervated by fibers of the internal laryngeal nerve, a branch of the tenth cranial or vagus nerve. There also may be some innervation by fibers of the lingual nerve, which is a branch of the fifth cranial or trigeminal nerve. Taste buds are known to degenerate when the glossopharyngeal nerve or the chorda tympani are severed. Sectioning of the trigeminal nerve causes taste buds of the front two-thirds of the tongue to lose function, though later the ability to taste may be restored. Harvey Cushing demonstrated that the trigeminal nerve does not participate directly in the innervation of the taste buds.

In structure, the taste buds may be spindle-shaped, flask-shaped, or ovoid, with an external layer of supporting cells. There is a generous lymphatic supply. Within are many elongated cells (some ten or twelve per taste bud) ending in filamentous processes which project through the central taste pore opening on the tongue surface. These hairs (intrageminal and perigeminal fibers) and the cells to which they are attached are entirely sensory in function, although the hairs are the parts actually stimulated. Near the root of the tongue are a number of V-shaped projections

called the vallate or circumvallate papillae which are covered with stratified squamous epithelium covering many capillary loops and nerve fibrils.

Taste buds that respond to *sour* stimuli are distributed mostly along the sides of the tongue, those responding to *salt* are located on the sides and tip, to *sweet* mostly at the tip, and to *bitter*, at the base. It appears that an individual taste bud can react to only a single type of stimulus

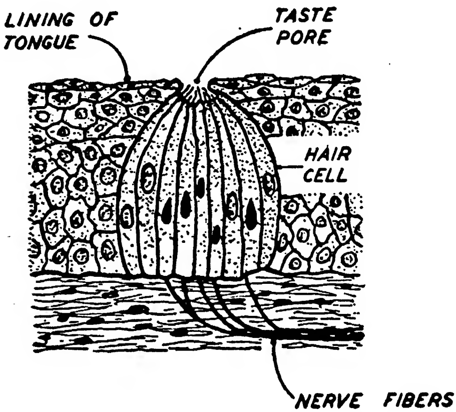


FIG. 3.—Section of taste bud, highly magnified. (*From Carlson and Johnson's "The Machinery of the Body. The University of Chicago Press."*)

although this has not actually been proved for bitter tastes. Taste buds on different areas of the tongue may detect different tastes when a single chemically pure substance is the stimulus. Those at the tip, for example, will detect sweetness and those at the base bitterness, when the substance para-brom-benzoic-sulphinide is applied.

The Sense of Taste

The stimulus to taste is a savory substance in solution, but dry substances may be brought to that state by saliva, for the surface of the taste buds must be moist to be stimulated. After continued stimulation of the taste buds, a fatigue point is reached, and for a time increased amounts of the savory substance fail to raise the intensity of the

taste sensation. The taste-sensitive entity in the taste buds seems to be continuously regenerated so that after a rest period of some seconds, or even minutes, depending on the intensity of the fatigue, the same buds will again respond to stimulation. The temperature and consistency of a substance influence its taste to some extent, but do so indirectly and not through stimulation of the taste buds. For accurate taste testing of various substances, they should be taken into the mouth in the form in which customarily eaten, at normal temperature and strength (at or near threshold concentration) in a neutral medium. During a test, the taster should concentrate on one taste factor at a time, disregarding the others.

Sherrington classified taste as an interoceptive or visceral sense. Unlike the visceral sensory system, however, the peripheral fibers of the gustatory sensory system have no connection with the autonomic nervous system, and the sensations experienced through it may be vividly conscious.

The most primitive and basic use of the taste sense is in relation to the choice of food; for the lower orders, it is the only criterion of choice. Generally, the organs in the lower phyla are distributed about the parts which crush, tear, masticate, and prepare food for consumption. The perception of taste in man organizes, if the stimulus is pleasant and appropriate, a reflex flow of saliva and of the gastric secretions. The deglutition (swallowing) reflex and the motion of the gastrointestinal tract may also be initiated by taste sensations.

The cerebral center for the integration and correlation of gustatory impulses and sensations is in the hypothalamus. All the gustatory fibers enter the medulla oblongata and end in the nucleus of the *fasciculus solitarius* by way of a root of the fifth or trigeminal nerve, which is intimately connected with all the motor centers of the medullary region where the mastication and swallowing reflexes arise. A taste center may exist in the cortex of the *gyrus hippocampi* near the anterior end of the temporal lobe. In fish,

this path is much longer and more highly developed than in man and can be followed to the midbrain where it synapses and continues to the hypothalamic region. The actual cortical path in man is not well established.

Among the invertebrates, sharp distinction between taste and smell is not always possible. The Insecta alone are able to separate these stimuli by different receptors. The gastropods, crustaceans, and worms perceive odors and tastes through a common sensory receptor, probably with a dual type of cell. This chemical sense among the lower phyla is useful in seeking the other sex as well as in locating and evaluating sources of nourishment. Without much question, however, the olfactory component is the more important. The gustatory sense may be very acute, as shown by the admiral butterfly, *Pyrameis atalanta*, which through the taste organs located on its feet has been shown to be 256 times more sensitive to cane sugar than is man.

The Sense Organs of Smell

The upper part of the nasal cavity in man (the superior *concha*) contains the olfactory cells, which are connected directly with the first cranial nerve (the olfactory nerve) by many slender olfactory fibers. The olfactory cells are laid upon a supporting epithelium, which if flattened would present an area of about 25 mm. square (roughly, 1 sq. in.). The color of the specialized epithelium is yellow or brownish, because of pigment cells. Projecting from the olfactory cells are a number of tiny cilia (about six to eight per cell in man). From the olfactory cells the nerve fibers pass through the cribriform plate and form the olfactory nerve. Eventually this leads to the olfactory lobes which organize the neural response. By this amplifying mechanism, the effect of a given stimulus may be greatly reinforced by excitation of many sensory cells. Impulses pass thence from the olfactory lobes to the thalamus.

In addition to the nerve fibers of the first cranial or olfactory nerve, there are other fibers which ramify over

the lower part of the lining membrane of the nasal cavity. These are branches of the fifth cranial or trigeminal nerve, the fibers of which enable the perception in the nasal cavity of feeling, including cold, heat, tickling, pain, tension, or pressure.

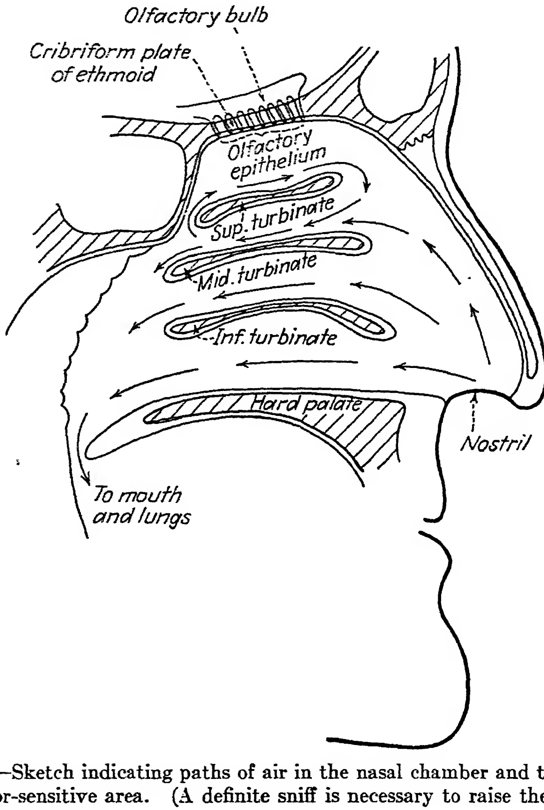


FIG. 4.—Sketch indicating paths of air in the nasal chamber and the location of the odor-sensitive area. (A definite sniff is necessary to raise the air to the olfactory epithelium.)

The hypothalamus and epithalamus of the human brain contain strong olfactory components. These parts are virtually a vestibule through which sensory nervous impulses reach the cerebral cortex. The ultimate termination of the olfactory fibers is in the eleventh area of Brodmann in the cerebral cortex, which is adjacent to the olfactory bulbs. Destruction of the thalamus by disease or

surgical means causes a permanent loss of olfactory sense. The importance of the olfactory function in the lower orders is evidenced by the large area of the brain occupied by the *rhinencephalon*, or "nose-brain."

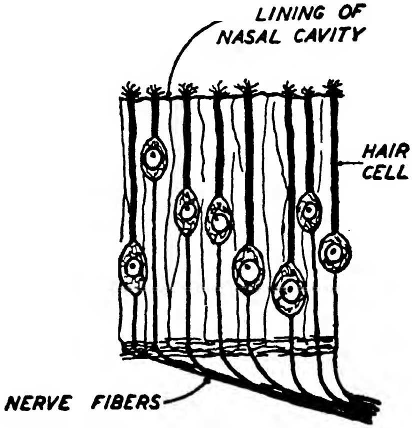


FIG. 5.—Section of olfactory cell, highly magnified. (*From Carlson and Johnson's "The Machinery of the Body," The University of Chicago Press.*)

Odors and the Sense of Smell

To be perceived as odor, stimulating particles must be inhaled into the nasal cavity in gaseous dispersion. Many believe that solution of these odoriferous particles must take place in the moisture of the membrane before they can react on the sensitive hairs of the olfactory cells. In some respects, this belief is not entirely logical, for many odoriferous substances, being predominantly of lipid-soluble type, are but slightly soluble in water. While solubility in water is slight, it may be sufficient. Again, lipids are present in the region of the sensitive cells. Sir Malcolm Dyson, in England, suggested that the odoriferous particles while still suspended in the air may transmit short-range electromagnetic radiation to which the fibrils of the olfactory cells are sensitive. The neurophysiological mechanism of smell offers a field for much additional research. There is also opportunity for the physicist to attempt to relate to odors some of the types of electronic spectra of

molecules to be found in the ultraviolet, the visible range, the near infrared, and the Raman spectra.

Voluntary smelling consists of a short and deep "sniff" after which respiration is interrupted. In ordinary breathing, the inspired air does not stream through the upper part of the nasal chamber, where smelling takes place. A definite sniff is required for smelling, and there is ordinarily no awareness of most odors without such an act to carry the odoriferous particles to the sensitive area. Odoriferous particles may also reach the olfactory epithelium by way of the mouth, especially during the act of swallowing when the posterior nares are wide open and not occluded by the soft palate. Much of the so-called "tasting" of food is actual perception of odor during swallowing.

If the concentration of aroma is below the olfactory threshold, there is no sensation of odor. On the other hand, if the concentration of odor-bearing particles is high and continuous, fatigue ensues; then no awareness of odor is possible until the olfactory epithelium has recovered. It is of interest to note that fatigue for a given odor is specific, although the olfactory sense organs which are in a fatigued state are diminished in acuity for the perception of other odors.

In certain abnormal physiological states, especially those due to neurological disease, the ability to perceive olfactory sensation is deranged. Most common is that in which a tumor at or in the vicinity of the olfactory lobes decreases or abolishes the ability to smell. A diagnostic test for the detection of tumors embodies the introduction of a definite volume of a volatile substance at a given pressure into the nostrils. The minimum volume in cubic centimeters of the substance which must be introduced before the odor can be identified is called the "olfactory coefficient." In an individual, any marked change in the olfactory coefficient with time or any wide departure from the average is assumed to be evidence of a brain tumor in the region of the olfactory lobes.

An upper respiratory infection which causes the nasal passages to be closed by mucus and other secretions but does not affect true tasting on the tongue makes an individual think that all foods taste alike. This fact corroborates the statement that much of what is called taste in food is really odor.

The interval between the reception of the stimulus of odor and the perception of smell is short, but the sensation lasts a relatively long time. In fact, there may be some perseveration, especially for the less pleasant odors. Since adaptation of the olfactory receptors occurs rapidly, it is extremely important to act promptly when odors warn of potential danger. The miners' traditional use of canaries and mice, whose olfactory threshold for methane is below that for man, was an early appreciation of the possibility of adaptation when subliminal odors are present over an extended period.

Very small quantities of substances can produce the sensation of smell. One five-hundred millionth part of a milligram (2×10^{-12} g.) in 50 cc. of air of any of several of the mercaptans is sufficient to stimulate the olfactory cells. Vanillin, artificial musk, and some other pleasant odors can be perceived in similar attenuation.

The thresholds for smell and taste differ enormously; one can smell extremely dilute substances but can taste only relatively concentrated solutions. The fact that the threshold for smell is lower than that for taste is the result of a complex mechanism for virtual amplification which is the summation and reinforcement of stimuli in the primary olfactory center of the olfactory bulb. The reflex path passes upward and backward to the epithalamus and hypothalamus, from which a descending nerve path runs to the motor centers in the cerebral peduncle. The olfactory bulb also discharges impulses into the olfactory cerebral cortex, which is contained within the hippocampus and from which associative pathways connect with all other parts of the cerebral cortex.

The olfactory sense is well developed among the Coelenterata and the Gastropoda, which depend upon it largely in finding food. Therefore, these phyla will fail to respond to food offered in a glass-covered vessel but may attack it ravenously when the vessel is uncovered. The search for the female by the use of the olfactory sense is well known among the Lepidoptera, a number of which have highly specialized olfactory organs in their antennae. Male insects will be attracted to a site recently vacated by the female, a fact which favors the conclusion that it is scent and not a specific emanation that is the source of attraction. The olfactory sense is a means of identification among ants, and when their antennae are removed they respond to each other with exceptionally aggressive behavior. Bees, entering or placed in a foreign hive, are killed immediately because of their foreign scent. Von Frisch believed that when bees have found a rich source of food they communicate with each other by means of an organ on the abdomen, which they cause to vibrate and to give off scent. Other members of the hive are then able to follow the trail of the finder.

The organs of smell are, in the invertebrates, distributed over large surface areas, especially in the Echinodermata, the Coelenterata, and the lower worms. In starfish and related orders, the organs are located on the multitudinous feet. In the higher invertebrates (the cuttlefish, for example) the suckers at the distal parts of the arms are most sensitive. Some of the Gastropoda have much-folded, hypertrophied patches of epithelium in the vicinity of the gills which may participate in olfactory function. In the bee, the olfactory organs are located in the terminal eight or nine joints of the feelers. The olfactory sense is intact when most of these joints are removed, although its acuity may be decreased if only one joint remains.

Chapter 3

Psychology in Flavor

FLAVOR memories are very keen and enduring, and this must be taken into account whenever food flavors are being originated or changed. Generally, there is an intimate association of flavor and circumstance, and when, perhaps years later, the one is duplicated, the other usually comes vividly to mind. Both odors and tastes give rise to many reminiscences, and even to nostalgic moments for some people, transporting them back to earliest childhood when flavors were first being met and when they were being registered most deeply in the mind. To the author, vanilla odor still suggests window gratings, encountered during early childhood in walks near a creamery where ice cream was being made in the basement. Coriander odor brings back memories of a little store that sold children's candies some of which were sugar-covered coriander seeds. The odor of naphthalene recalls an incident of being lost and coming home so hungry that moth balls were eaten as the first "edible" thing in sight.

When flavor impressions recall memories, one may revel in the sensation or, as aging people often do, may contrast present flavor enjoyment unfavorably with that of the past. One's senses are keener, to be sure, when one is very young, for then each new flavor registers strongly and clearly on a fresh clean page of the mind, whereas, as one grows older, nothing is as clean-cut or thrilling, for each sensation is but one of many. However, for those who are alert and eager, each successive tasting is better than the last because

it is better discerned and appreciated. What is the "muddle" of related sensations to some becomes for the alert a background into which each new experience is fitted in its proper place to constitute a cumulative flavor "file."

FIG. 6.—Absence of attractive flavor may start a lifetime of dislike. (*H. Armstrong Roberts.*)

A corollary to the strong associations between flavors and events is the prejudice in many people's minds regarding certain flavors. If the first meeting with the flavor was unpleasant, the second may suggest unpleasantness, and each subsequent meeting will help to establish an intense dislike. This is especially true of anise and other flavors that are often used to hide the taste of unpleasant medicine. Sometimes "innocent" flavors or textures such as those of

oatmeal cereal, cornstarch pudding, or jelly recall with great distaste some episode of sickness. The flavor of parsnips may recall a punishment one received for not eating this vegetable on the first presentation. These prejudices may seem childish, yet they are ingrained and hard to overcome. They demonstrate how deeply some seemingly trivial matters may affect our habits and even our happiness and, also, how important flavor is in this connection.

Strong likes as well as dislikes for flavors can also be developed by the mechanism of association. We become accustomed to certain flavors which seem natural and proper, for which we have a hankering if they are not occasionally enjoyed. Whole populations are affected in this way, such as the Mexicans for chilies and for cumin and the Mediterranean peoples for garlic, oil, and pepper. There are racial or country-wide dishes that assume almost a religious or patriotic status through ceremonial association. Each holiday or other occasion has some proper flavor. Even color may be associated with flavor. A red mint candy, for instance, seems entirely out of place, whereas pale-green is appropriate.

A person's reactions toward flavors are exceedingly characteristic and natural. A conservative person tends to be conservative in what he likes in flavors, and a reckless, daring person, the opposite. Likewise, one who demands variety and frequent change in other respects tends to do so with flavors. Those who are ascetic in character refuse to enjoy flavors; others who are more sensuous indulge the palate accordingly.

Gastronomes, or food-conscious people, seem to fall into classes according to their adjustment to life. Some folks eat for eating's own sake and others to compensate themselves by the delights of the table for some serious lack of satisfaction obtained in other directions. Many go in for sheer quantity of good things. These are the *gourmands*, who stuff as though the pleasure of the day is all they

expect to have. Others combine restraint with enjoyment. These are the *gourmets,* who enjoy not only the journey but also the prospects of the destination. The original meaning of *epicure* was a Spartan-like person who consciously avoided taking any pleasure in eating. Today epicure has a meaning similar to gourmet.

A person may train himself to recognize new flavors and to like them. It is also possible to discipline one's self to overcome at least certain prejudices and dislikes. Many people, however, have no desire to change their tastes, feeling that their likes or dislikes are judgments not to be questioned but obeyed.

Appetite is psychological. It is the desire to eat, suggested by one of many possible stimuli or by habit. Hunger, however, implies a need. It is physiological, being caused by hypoglycemia and accompanied by marked contractions of the stomach. A similar relationship holds for food and nutriment. Food is what is desired, while nutriment is what is needed. The tendency is to think in terms of particular items rather than of food in general, regardless of whether one is in need of nutrition or merely desirous of food.

Perhaps the original function of flavor was to protect the individual in his choice of what was fit to eat. Flavor perception and reaction operate at a low, nearly automatic level of the mind and are well adapted for such protective function. There is only one truly natural food—the milk of one's own species—and even that is natural only in infancy. Even at that age all other foods are selected from available materials. The flesh of most animals is safe and good to eat, and our ancestors used it freely. For both animal and vegetable foods, one is accustomed to particular identifying flavors. As one develops discrimination, shape, color, texture, and even particular packs and trade names are added to the identification clues. Only the familiar is freely acceptable to most people.

Chapter 4

The Language of Flavor

A SUBJECT with as much popular and technical importance as flavor naturally has a well-defined language, even though many of the descriptive words used may have different meanings when applied to subjects other than flavor. Some elements of flavor are relatively easy to describe for the general public and for the food technologist. Other elements, especially those dealing with odor, are inherently difficult to express, and there may be wide differences between popular, technical, and scientific concepts and terms. In common with advances in other arts, however, it is to be expected that these differences will decrease with time.

Over two thousand years ago the Greeks had already acquired many terms for flavor, and we are especially indebted to the Latin poet Horace for a record of these and for the expression of a surprisingly mature accompanying philosophy: "If your steward is away, or the sea is too rough for fishing, cravings within you will be satisfied with a little bread and salt. How does this come about? Most of the pleasure is in yourself, not in the odor of expensive food. Hard exercise is the best sauce. The fat, sallow gourmand cannot enjoy oysters, scar, or imported lagois." The Greeks also had a "modern" approach to the impersonal, objective expression of flavor in their "nine tastes": *sweet*, *salty*, *sour*, *bitter*, *astringent*, *dry*, *pungent*, *vinous*, and *oily*. Unfortunately, this fine analytical viewpoint was lost in time, and for centuries the flavor words,

as indeed the concepts behind them, went through many flickerings before a general steadying and emergence about the time of the Renaissance.

In the early seventeenth century, many new foods appeared in Europe. Chocolate, then coffee, and finally

Fig. 7.—A powerful milling operation controls consistency, an important part of the flavor of chocolate. (*Courtesy of Walter Baker & Co., Inc.*)

tea became widely known, all within the thirty years prior to 1660. Great numbers of other exotic foods brought back from all over the world, but especially from the American tropics, by the explorers of a few generations earlier were becoming common. Among these were the turkey, squash, string beans, tobacco, and other important plants. Probably there was never a time when more new flavors suddenly became available than in the seventeenth

century. This wealth of new foods, plus the beginning of a widespread commercial prosperity that permitted many to purchase something more than bare necessities and to enjoy life in clubs and inns, aroused a great interest in flavor and resulted in the coining of new flavor terms. In France, especially, a notable popular interest in good food developed, and many capable chefs and caterers appeared, each with his contribution of new terms.

Flavor terms are always more or less in flux. Perhaps this is true of words of all kinds, especially in such a dynamic and versatile language as English. Once to *taste* meant to *touch*, whereas today it means sensations produced when certain things touch the tongue. Likewise, *flavor* once meant simply *odor*, while today it encompasses all the sensations produced by anything that enters the mouth, whether it be food, beverage, tooth paste, medicine, or tobacco.

Flavor sensations involve no less than three of the five senses: smell, tongue taste, and feeling. The *aroma* of a food registers on the sense of smell only. Any aggressive odor, such as that of freshly roasted coffee, may be noted by *whiffing* or *sniffing*. Less aggressive aromas may be discovered only when the foods possessing them are eaten. There is a route from mouth to nose for aromas to travel, and unless one is careful he cannot be sure whether he *tastes* the flavor on the tongue or *smells* it by the route through the head. Frequently, flavor is a mixture of both types of sensations. Feeling is involved when foods, such as spices, *tingle* or feel *warm*. The taste may be *puckery* with an *astringent* such as tannin, *biting* with mustard, or *cool* with peppermint. The appearance of food, its appeal to the sense of sight, is also important. The same is true of sound as, for example, when one bites an apple or breaks a cracker.

The Terms of Taste

The specific taste term *sweet* means today the taste of sucrose. Probably, in earlier times, it referred to the taste

of honey, which has not only sweetness of taste but also a pleasant aroma. It is even possible that the terms sweetness of odor and sweetness of taste both came originally from descriptions of honey. Indeed, the terms *honey* and *honeysweet* are still in use and have generally pleasant connotation, whereas *saccharine*, *sugary*, *sirupy*, or *treacle* have mostly textural associations. Other words in com-

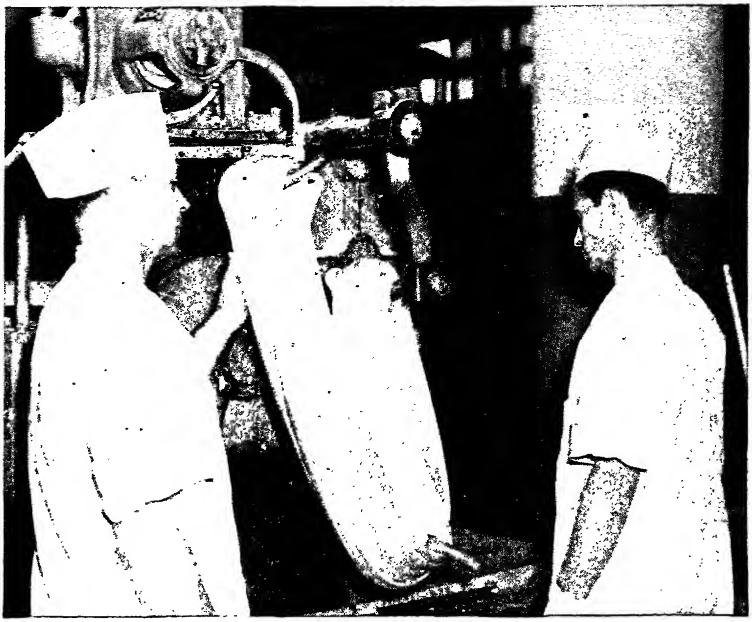


FIG. 8.—Taffy and other chewy candies are pulled by machine to develop brittleness and fibrous texture. (*Courtesy of New England Confectionery Company.*)

mon use to describe sweetness are *sweets*, *candy*, and *confectionery*. Older terms of similar meaning are *sweetmeat* and *sugarplum*. *Taffy*, with its mixture of sweetness and saltiness and with its sticky and tenacious consistency, is used to denote texture rather than taste. *Fudge* was named after "nonsense." When *sweetness* is too great, it clogs the taste buds and is called *cloying*. The opposite condition, in drinks, is called *dry*. The term *dulcet*, while old-fashioned and applying more to sound than to taste,

suggests refinement and a delicate but prominent sweetness. *Glucose* might be a better-liked name today did it not suggest glue. It is more appetizing to refer to the sirupy composition as *corn sirup* and to the pure crystalline material as *dextrose.*

Slightly *acidulated* water has *acerbity,* or *sourness,* but if the *acidic* content is increased, it reaches the *tart* point and thereafter will be frankly *acid.* As far as possible, the word *sour* is avoided in connection with food, for the spoilage association is very strong. It is better to use *tartness, sharpness,* or even *acidity;* for these terms, while strong, are free from any unwholesome associations.

Saltiness of water is expressed in increasing degree by the series of terms *brackish, saline,* and *salty. Brine* is a salt solution used for pickling meat or cucumbers. *Pickling* nowadays calls to mind the use of vinegar at the end of the processing rather than to the *salting* at the start of the process. To *marinate* once meant to *pickle* in salt, but today it means flavoring with herbs, spices, wine, and vinegar, and sometimes with oil, following the initial *salting.*

Bitterness is prominent in caffeine, quinine, strychnine, and most of all, brucine. Many herbs taste *bitter* but sometimes also have a content of tannin, which tastes *sour* and *astringent* as well.

General Flavor Terms

Salt is the most important single *seasoning.* Insufficiently salted food is called *tasteless* or *insipid.* The term *unsavory* is reserved for flavor of an *unpalatable* kind. It may imply that the taste is *offensive, sickening,* or *nauseous.* A slight *off-flavor* that is acceptable in a food is called a *tang. Tang* means *pricking,* and as applied to flavor has been defined as "a sharp specific flavor or tinge" or as that which "pricks or spurs one on"; also, more broadly, as "a strong and offensive lingering taste; especially a taste of something extraneous to the thing itself; as wine or cider

with a tang of the cask." An even stronger term for wild or crude flavors is *foxy*, a term which has been defined as "defective in some way as to color or quality, as from age, decay, etc.," or, if taken literally, as "having the odor of a fox; rank, strong-smelling," or as "sour, unpleasant in taste; said of wine, beer, etc., not properly fermented, also specifically of grapes with a coarse flavor."

Particularly tasty foods may be called *savory*, *flavorsome*, *delectable*, or *toothsome*. Fruits can be *luscious* and drinks are *ambrosial*, or like *nectar*. Some nouns applying to *fine flavor* are: *goût*, *smack*, and *gusto;* and to a *piquant taste: zip*, *zing*, *nip*, *zest*, *spice*, *snap*, *relish*, *dash*, and *kick*. Two antique words, *savor* and *sapid*, are equivalent to the modern terms *flavor* and *tasty*. Process words are common, such as *season*, *salt*, *sweeten*, *spice*, *toast*, *pickle*, *cool*, *frost*, *curry*, and *devil*.

The Terms of Touch

If an odor is strong in the elements of touch, it may be called *pungent*, *sharp*, *acrid* or *stinging*, or occasionally, *cool*.

Feeling, *palpable* or *tactile sensations* in the mouth, includes the *sting*, *bite*, *piquancy*, *poignancy*, or *authority* of a strong spice such as mustard or pepper, the *astringency* of alum or of an unripe persimmon, the multiple unpleasantnesses of chlorine or iodine or of certain *metallic* tastes, the *warmth* of ginger or pepper, and the boreal *coolness* of peppermint. *Greasiness* or *oiliness* are also a part of feeling. Fizz water *tickles* as the "needles" *prick* gently. Oil of cloves may produce a feeling of *numbness* on the tongue. The lasting feeling of satisfaction enjoyed after eating soups or sausages containing sodium glutamate may be called *mouthfulness* or *Vollmündigkeit*.

The Terms of Odor

The presence of food is often impressed upon us through its *aroma* acting on the sense of smell. The *odoriferous* greeting received when we come into the house just as a

turkey dinner is being made ready for the table is an important part of the flavor, acting at a distance. The term *aroma* applies to the *emanations* from cooked foods. *Bouquet,* however, is a better word to describe the *ambrosial fragrance* or *essence* of a fine wine, and *perfume* is more accurate for the *exhalation* from Marshall strawberries, Concord or Delaware grapes, or sun-warm raspberries. While we speak of sweet odors from afar as *balmy,* we refer to the same *scents* at closer range as *spicy, savory,* or *aromatic.*

If a substance *gives off* or *emits* a *foul* odor, it may properly be said to *stink* or to *reek,* and the *exhalation* may be called a *stench,* a *stink,* or a *fetor.* We may be more specific and describe a particular odor as *smoky, empyreumatic, burnt, sulfurous, gassy,* or *sour.* A *malodorous* cheese may be described as *moldy, musty, fusty,* or perhaps *rancid,* although this last term is usually reserved for *spoiled* fats. A partisan for such strong cheese may counter this terminology, speaking only of its *redolence* or its *fidelity to type.* Other unpleasant odors may be *mephitic* if sufficiently *skunky* or *goaty;* but only rarely will they be bad enough to be called *rank, noisome, fulsome, palling, putrid, effluvial,* or *nauseous.* Meats slightly *tainted,* generally through lack of refrigeration, are called *high* or, sometimes, *racy.*

The term *stink* has unfavorable connotation and denotes strength of *odor* of an inappropriate kind. Otherwise, it is nonspecific. Perhaps a *stink* among *odors* may be compared with a weed among plants. A weed has been defined as "a plant out of place," such as a potato in the flower garden or a petunia in the vegetable garden. It is an optimistic statement, attributed to the late George Washington Carver, that "a weed is a plant for which no use has yet been found." The first *fumes* during the cooking of sauerkraut and the odor of the durian fruit, while associated with desirable foods, are to be classed as *stinks.* While the odor of rancid fat (*tallowiness*) is generally called unpleasant, it is desirable in Roquefort cheese and in

Indian ghee and is tolerated in peanut butter. It even contributes to the appetizing odor around a doughnut bakery.

A person *sniffs* gingerly in smelling an odor that is strong or is not especially pleasant, but *whiffs* or *inhales* strongly to acquire the complete olfactory sensation of a fine *aroma* of pleasant promise.

Scientific and Technical Flavor Terms

The taste terms in general use which are sufficiently accurate for scientific and technical application are: *sweet, sour, salty,* and *bitter.* The mouth-feeling terms, *numbing, astringent, warm, cool,* and *biting* are specific and objective. *Peppery* and *alkaline,* while probably not elemental, likewise are generally understood and applicable. With these few words there is little trouble in conveying to nearly anyone accurate impressions of true taste or mouth feeling. The assumption is that most people have normal taste organs and sensations, which is probably true in spite of the few who are *taste-blind,* especially to *bitter.* This assumption is not safe, however, with odors, which supply much of the interest to flavors. Odors, being more complex than tastes, are less tangible. The terms used to describe them, therefore, need to give more assistance if odor impressions are to be conveyed accurately. Scientifically, this can be done with a few terms and some figures. Technically, odors are most frequently described in terms of *like x* or *like y,* and so forth, where the person is required to be familiar with enough x's and y's for proper comprehension.

By the Crocker-Henderson system, an odor may be represented as a four-digit number. The first digit is the measure of relative *fragrance,* the second of *acidity,* the third of *burntness,* and the fourth of *caprylic* character. Each component in the odor in question is determined by comparison against the same component in the odors of the chemicals of a set of accepted standards (see Table 1 and Fig. 1). One can usually learn rapidly to focus his atten-

tion on one component at a time, to the exclusion of the other three, to obtain the numerical rating.

Every odor has some value of each of the four components. Its distinctiveness is in the relative values of each. Sweet floral odors, spices, musk, and most perfumes are high in fragrant, whereas vinegar is high in acid. Burnt is prominent in the odor of many substances which result from chemical changes at high temperature, such as singed or burnt flesh, toasted bread, roasted coffee and tar, but also is conspicuous in the odor of the skunk. Caprylic is another word for *goaty* and denotes the unpleasant type of odor associated with the billy goat. In dogs, especially when wet, and many other animals, this odor characteristic, as well as burnt, may be strong.

Some examples of odor "formulas" or designations are as follows: oil of wintergreen is 8 in fragrance on the scale of 8, 4 in acid, 5 in burnt, and 3 in caprylic. Stated simply, its odor formula is 8453. Likewise, the odor formula for vanillin is 7122, and that for beechwood creosote, 7584. By this system, digits virtually comprise the "language" of odor.

Chemically trained people frequently refer to odors as similar to those characteristic of well-known chemicals, as *phenolic, sulfury, ammoniacal, alcoholic, camphoric,* or *mentholic,* or to particular ingredients present, such as *vinegary, fruity, mustardy, grapy, lemony, resinous, garlicky, almondlike, eggy,* or *oily.* The much-used court of last resort is based on resemblance, either of the whole odor or of a distinguishable part, as *fishy, keroseney, winy, nutty, musty, chalky, argillaceous, grainlike, earthy, flowery, tobacco-like,* or *tarry.* Some specific terms of the tea taster, as *bakey* or *weathery,* may give implications of the cause of the characters noted.

With all the wealth of terms available for describing flavor, as a whole or in its details, it is to be hoped that no longer will great numbers of food flavors be described merely as *characteristic.*

Chapter 5

Natural Sources of Taste

MAN is omnivorous, eating nearly every kind of wholesome plant and animal. Distinctive tastes exist, not only for each variety, but frequently different flavors characterize each part thereof. In making an inventory of the tastes of the products of nature, it is convenient to consider first those of plants and then of the animals that eat the plants. One may start logically at the ground and consider the flavors of roots, then of stems, wood, and bark, next of leaves, buds, and flowers, and finally those of fruits and seeds. After that, one may describe the flavors of meats. One may then review the flavors of the ocean and other bodies of water and of their flora and fauna.

Flavors in Roots

Tender roots are widely used as vegetables, especially those which may be stored. Some of these roots are conspicuously sweet, because of a high sugar content; others are strongly flavored with aromatic oils. Many woody roots are sources of medicinals and, occasionally, of usable flavoring substances.

Sweetness due to sugars is conspicuous in sweet potatoes, yams, Jerusalem artichokes (a variety of sunflower), parsnips, carrots, and beets. Onions and garlic also are very sweet, but their sweetness tends to be hidden by the strong aromatic content.

Sharp, biting tastes of isothiocyanate origin are present in members and relatives of the cabbage family, including

phenylethyl isothiocyanate in the radish and turnip, and butenyl isothiocyanate in horse-radish.

Roots of the carrot family, including celery, lovage, angelica, carrots, parsnips, and fennel, have a strong, sweet taste combined with essential oils, a considerable portion of which is driven off when these vegetables are cooked.

Onions and garlic are sweet bulbs flavored with minute quantities of intensely odoriferous sulfur compounds that are not too well known. Onion aroma is believed to contain, besides disulfides, traces of allyl aldehyde and possibly some allyl isothiocyanate. Cooking drives off a large part of the volatile flavor of onions. Garlic aroma contains allyl propyl disulfide and diallyl disulfide.

Gingerroot contains a peppery-tasting, nonvolatile oleoresin and a fragrant essential oil. Licorice root is rich in the intensely sweet glucoside, glycerizin, which is also astringent and somewhat bitter. Sassafras root depends for its flavor on the presence of an essential oil. Rhubarb root, chicory, and gentian root are bitter and aromatic. Orrisroot has traces of a violetlike essential oil. Galanga, gentian, and dandelion roots contain bitter substances used in medicines and beverages.

The tongue-stinging character of many roots of the arum family, such as that of Indian turnip (jack-in-the-pulpit), is due to the presence of minute needlelike crystals of calcium oxalate. These roots are made edible by boiling, which destroys the stinging crystals. The Hawaiian plant taro, used for making poi, is an important food source in this family.

Flavors in Stems, Wood, and Bark

Soft edible stems include celery and fennel, which contain essential oils; and the sour and astringent herbs, rhubarb, Swiss chard, and spinach, which contain oxalic and other acids together with some calcium oxalate crystals.

White oakwood is notable for its content of soluble matter and is utilized extensively for the bodying and flavoring of

alcoholic liquors. In Europe, plain white oak barrels, and in this country and Canada, mostly, charred white oak barrels, are used for the storage of whisky, rum, brandy, and some wines. During the storage period a very appreciable quantity of "extractives" is removed from the wood by the dilute alcohol, to furnish color and flavor directly. Further flavor results from the reaction of the "extractives" with the alcohol present, to produce esters. Occasionally, vinegar, cider, and other food products are "aged in the wood," to provide rich flavor.

Barks of interest are those of cinnamon and cassia, which contain sweet and aromatic essential oils; slippery elm, which is mucilaginous and aromatic; witch hazel, which is aromatic; and wild-cherry bark, rich in astringency and in a glucoside which gives an aromatic flavor on hydrolysis. Angostura and many other barks are used in medicines and beverages, principally to furnish astringency, bitterness, or both. (The well-known Angostura bitters, however, were named for the town of Angostura in Trinidad, rather than for any content of angostura bark.)

Flavors in Saps, Gums, and Other Exudations

Honey is a plant exudate gathered by the bee. It is essentially a 70 per cent sirup of invert sugar, colored and flavored delicately by the flower that produced it. Maple-tree sap is a sweet but otherwise insipid material as obtained from the plant. The well-known maple flavor is developed during a boiling-down operation. Cane sap also starts insipid, develops considerable flavor during concentration, and then is separated into two products: purely sweet sugar and tangy molasses.

Spruce gum has a fine resinous flavor but is rarely used for flavoring. Gum benzoin, however, is used in medicine and occasionally as a flavor in cake icings. Gum guaiac, patented for use as an antioxidant for animal fats and not ordinarily used as a flavor, has a mild vanillalike aroma.

Manna, gum arabic, gum tragacanth, and a few other insipid or sweetish exudations are used principally as mucilages to produce a "false body" that is important in the feeling part of flavor.

Flavors in Leaves

The salad type of greens, including the many kinds of lettuce, endive, dandelion, and chicory, contain much bitterness and some aroma. Cabbage, turnip tops, Chinese cabbage, and water cress contain biting flavor because of traces of mustard oils (isothiocyanates); spinach and Swiss chard contain oxalates, making for astringency and sourness, whereas parsley, fennel, and celery leaves depend chiefly on aromatic oils for their flavor.

Of herbs, there are legion: dried or green leaves used for teas, smoking, flavoring agents, and medicines. Many contain tannins which make them astringent as well as give them "flavor body"; many others contain bitter glucosides or alkaloids, besides the essential oils which give them aroma. Ordinary green tea best represents the tea plant, for black teas are made by fermentation. Paraguay tea, known as maté, is also a fermented leaf, generally dried in hardwood smoke. The smoky aroma makes it attractive to the South Americans, who are accustomed to it, but somewhat strange to many in North America, who do not associate a baconlike flavor with a beverage. The class of tisanes, or herb teas, includes camomile, costmary, lemon verbena, lemon balm, catnip, and linden flowers (*tilleul*), which make excellent beverages. Although these herbs lack caffeine, they are often used as alternatives for tea. The flavoring herbs that are dried, including sage, wintergreen, thyme, savory, marjoram, horehound, dill, and catnip, are rich in essential oils. This is true also of sweet basil and borage, which are generally used fresh and, to a great extent, of the medicinals. Wormwood leaves are intensely bitter as well as aromatic.

Through occasional testing over a long period of time, certain herbs have been selected for use in flavoring. The common stuffing for a turkey nowadays must contain dried sage and thyme, blended with marjoram or savory. Tomato dishes and boiled fish are notably improved by an addition of fresh leaves of sweet basil; various soups and vegetables may be flavored interestingly with celery, parsley, thyme, rosemary, rue, pineapple mint, winter savory, or sage. Chives give a mild suggestion of onion flavor to soups or cheeses, which is acceptable to many who are not able to eat onions. Tarragon and fennel give a sweet anisy touch to salads, sauces, and vinegars.

Flavors in Buds and Flowers

Masses of flower buds from broccoli and cauliflower are used as a vegetable. The flavor of these flowers is like that of the leaves of the plant but milder.

Orange blossoms furnish the essential oil of neroli, used in traces to aromatize beverages. Attar or oil of roses is used in flavoring snuff; and the oils of roses and of certain other flowers, including jasmine and violets, find occasional use for flavoring candy and soft drinks. In these instances, the oils are extracted and used as such. In the making of scented teas, actual jasmine flowers are mixed with the tea to impart their flavor but are removed before the tea is used.

Clove-blossom buds and short stems provide the highly aromatic spice "cloves."

Flavors in Fruits

Fruits are the fleshy structures that carry the seeds of the plant. They include the many varieties of berries, pepos, hesperidia, drupes, pomes, aggregate fruits, and collective fruits. Berries include the blueberry, grape, huckleberry, tomato, and the banana. Pepos are exemplified by melons, cucumbers, and squashes; hesperidia by the citrus fruits; drupes by the stone fruits; and pomes by

apples, pears, and quinces. Aggregate fruits include the strawberry, raspberry, blackberry, loganberry, and boysenberry; and collective fruits, the mulberry, fig, and pineapple.

Nearly all fruits are sweet and many are also sour, because of a content of malic, citric, or tartaric acids. The presence of tannic acid is rather general, and in the apple it is essential for "body" and a good tangy flavor. It is especially important if the apples are to be made into cider. In the green wild persimmon, astringency is objectionably high. The tannin, and the pectin, in plums—especially beach plums—and the bitterness of citrus-fruit rinds make these fruits useful for highly flavored jellies, jams, and marmalades. Essential oils are prominently present in the colored outside layer of the skins of citrus fruits but are practically absent in the pulp. With many other types of fruits, including apples and strawberries, the aroma is concentrated in and just below the skin. Whatever aroma is present in other types of fruits is due to essential oils, which may be located in the skin or in the pulp. These oils are very sensitive and can rarely be separated from the fruit without some destruction. However, when aromatic ripe strawberries are agitated with chloroform and the extract is allowed to evaporate, there is a split second, just as the solvent disappears, when one may smell an extract that has the full aroma of the berry, plus the oiliness of the seeds. Only in a few instances are the compositions of the sensitive fruit-flavor oils known. Rough equivalents of them have been produced as artificial flavors that are valuable for use in hard candies, baking, gelatine desserts, and in other items where the true fruit flavor does not endure processing and keeping. Even carefully preserved strawberries, peaches, and pineapples have flavors radically different from those of the fresh fruit.

Flavors in Seeds

Seeds include, on the one hand, such spices as allspice, nutmeg, cardamom, caraway, celery seed, tonka beans,

coriander, vanilla, anise, pepper, and mustard, which depend for flavor on essential oils; and on the other hand, the nuts, which are very fatty and somewhat astringent but not otherwise distinguished, and the cereals and legumes.

Coffee, cacao beans, and peanuts are seeds low in flavor in the natural state. They develop their principal and distinctive flavors on roasting.

Seeds of kola are bitter from caffeine and astringent from tannin. Fenugreek seeds yield a water extract with a great deal of flavoring value suggestive of maple or slippery elm. Some kinds of beans, including soybeans, may be excessively bitter, but this bitterness can be destroyed by moderate heating.

Flavors in Meats and Meat Products

Much has been written about meat flavor, but the subject is still far from clear. Meat flavor is due to something more than sodium glutamate, a substance that contributes much to developing a good chicken flavor in soups and makes vegetarian food more satisfying. Part of the flavor of meat is apparently due to slightly volatile organic acids, and perhaps part is due to nitrogen bases. Long-cooked meats have "soup stock" taste which is dextrinelike in character. There is reason to believe that the flavor strength which develops in cooking any meat is somehow connected with the color of the meat; and the darker the meat, the stronger. The implication is some relationship of flavor to hemoglobin. When protein and fat are heated together, "cooked meat" flavors are created. For the production of consommé with plenty of flavor, at least a part of the meat used should be that of old animals. The distinctive flavor of the various meats, while mild, is noticeable, and on cooking may become strong. The identification of the responsible agents is a task for the future.

Of the animal organs, the gall has strong bitter flavor. Liver frequently has some bitterness, but the taste of the

other organs is relatively slight. Recently an attempt was made to introduce animal scent-gland extracts into foods, to intensify flavors such as maple, vanilla, coffee, and walnut in ice cream. The normal flavors of milk and cream are low. It is only when these products are fermented, to butter, kumiss, or cheese, that strong flavors develop.

FIG. 9.—Roast beef of finest flavor. (*H. Armstrong Roberts.*)

Flavors in Marine Products

Sea salt is not suitable for most food usage without purification to rid it of its bitter magnesium content. However, sea water may be used in the making of bread to furnish both water and salt.

Seaweeds, including agar-agar, Irish moss, and the Pacific kelp, are notable for their content of mucilaginous material which may be used to give texture to foods and in that way to influence the taste. Some seaweeds, such as dulce, have relatively strong specific flavors, at least when dried.

Fish, even from the ocean, are relatively free from salt, and practical use of this fact is being made by shipwrecked sailors and others to secure a supply of potable water by macerating and squeezing the flesh of fish. The odor of fresh fish, although stronger than that of meats, is slight.

It may be described as like the odor of weak nitrogen bases of the general type of piperidine. When fish is poorly kept, it first develops "fishy" odor as a result of the release of methyl amine, and later develops foul odor as a result of the release of volatile sulfur compounds. On cooking, the flesh of most fish and crustaceans is found to be distinctly sweet, and that of clams, scallops, and other shellfish markedly so. Oysters are more or less bitter and astringent in addition to sweet; this is due to an appreciable copper content.

Traces of Strong Unpleasant Substances in Natural Flavors

Practically every natural odor has in it ingredients, often sulfur or nitrogen compounds, which are distinctly unattractive in themselves and occasionally very rank and unpleasant. Sometimes, as in peppermint and spearmint oils, the traces of foul sulfur compounds and resinous ketonic odors are not desirable, but are merely tolerated. In the extra-refined oils they are largely removed. Foul odors may be an essential part of the flavor, as, for example, the traces of a sulfur compound which give a wild note to tangerines, and the minute content of indole, which produces a heavy fragrance in navel oranges. The only reasonably satisfactory strawberry imitations contain a trace of oil of onion. It is said that the durian fruit of Malaya contains such a high sulfur content that it is like a custard made from eggs not too fresh. Guava contains butyrates, which, in traces, *e.g.*, in butter, are interesting, but in higher concentration may suggest perspiration.

Most of the highly distinctive natural flavors contain taste and feeling elements which alone would be unpleasant, but which are desirable in the total flavor. Important among these are the sourness and astringency of tannin, which make much "body," the bitter of glucosides, and the sprightly acidity of temperate zone fruits. Some fruits, such as wild cherries and beach plums, while too strong-tasting for table use, have a fine blend of flavoring

ingredients which is excellent in dilution and can be used to add life to more insipid fruits in making preserves, jams, or beverages.

Horticultural development of fruits and vegetables has greatly improved resistance to plant diseases and has had influence on flavor as well as on yield, shape, and appearance. Most improved varieties have less tang than that often characteristic of the wild forms and sometimes objectionable in them. In general, tastes are now weaker than formerly and odors much weaker. Reduction of the astringency of the persimmon and of the grainy texture of pears caused by stone cells are positive gains. Cultivated strawberries, however, while better-tasting than the wild, especially when cooked, are generally far inferior in aroma. The prolific straightneck summer squashes are watery in texture and inferior in flavor when compared with the old scraggly crooknecks. Many of the newer varieties of sweet corn lack sweetness and aroma. It appears that the trend recently in fruits and vegetables has been too much toward insipid creations with disease resistance, yield, and eye appeal, and in flowers it has been toward large and colorful blossoms with weak or missing odors. Surely it is time to raise the sights a bit by demanding vegetables and fruits that shall have superior flavor as well as stability and fine appearance. This plea should be extended to include flowers with the odoriferous "personality" of the wild forms.

Chapter 6

Significant Elements in Popular Flavors

PRACTICALLY every food and beverage that has become a popular part of everyday living has some distinctive element or "kick" for producing satisfaction. Items that are inherently good may often be put into the successful group by attention to kick. The kick may be a stimulant producing a physiological reaction, as with caffeine, alcohol, or tobacco, or it may be a satisfying sense stimulation. Instances of both kinds are given below, regardless of whether the substances producing the kick are of natural or synthetic origin.

It was discovered in collecting these items that all of the stimuli involved are for the senses of taste and feeling located in the mouth. Apparently, under ordinary conditions, entirely insufficient quantities of substance reach the smelling area to cause any valuable direct stimulation by way of odor alone. That the aromatic element counts, however, even if no aromatic ingredient is self-sufficient, may be appreciated from the facts that kola drinks without aromatics are of slight interest, and coffee without aroma would be repulsive.

Salt must be featured in any list of especially satisfying flavor ingredients. Unless a fair proportion of salt is present, nearly all starchy and protein foods are uninteresting. Even in some kinds of candy, such as fudge or taffy, salt has its place. It becomes just noticeable when

the proportion is between ½ and 1 per cent. In most foods that proportion must not be exceeded.

Sugar and other sources of sweetness, such as glycerin, licorice, oil of cassia, or oil of anise, are important constituents of many flavors. Saccharin and dulcin, however, should be considered only as taste correctives for medicinal use, for they may not legally be used in foods, even should indication of such usage appear on the label.

Acids are of great interest in foods. Some, such as acetic, propionic, and butyric acids, have aroma value, whereas others, including tartaric, citric, carbonic, and phosphoric acids, are nearly or quite odorless. Beverages, especially, depend upon a particular pH and also upon a particular total or reserve acidity if they are to have the correct instantaneous and follow-through sharpness of taste.

Bitter substances are of importance, not only in beverages, but in all highly flavored foods. The bitter substances caffeine and theobromine will be considered separately in the next paragraph, under stimulating properties. The hops of beer are bitter. Gentian is of value in beverages and in medicinals. Wormwood is occasionally used (*e.g.*, in absinthe). One of the services of spices, and especially of herbs, is to provide bitterness, a quality liked for itself, but also a quality that together with saltiness and sourness may be used to counter excessive sweetness, and with sweetness and sourness to balance too much necessary saltiness. All the taste elements must be present if there is to be a strong flavor in good balance.

The substance *caffeine,* and to a somewhat less extent its relative theobromine, because of its stimulation or lift, is the kickmaker in all the popular hot beverages of the past, including tea, maté, cassia and cocoa. It is also present in the cold, carbonated "kola" drinks that have recently won enormous popularity.

It need scarcely be noted that *alcohol* is the source of principal interest in fermented and distilled beverages. Since the taste, the aroma, and mouth feeling of alcohol are

not particularly pleasant, relatively strong flavors are needed to counteract these qualities to produce distinctive and lastingly popular beverages. Woody flavors are standard in distilled liquors, including white oak barrel flavor for whisky, arrack, rum, and brandy, and juniper berry flavor for gin. The bitterness and aroma of hops are standard flavor for the cereal liquors. Fruit-juice residuals, containing tannins, and often some "wood," are prominent in the flavors of ciders, perries (pear ciders), and wines. Cordials and liqueurs are distilled liquors, usually sweetened, and strongly flavored with herbs, spices, and fruit juices.

The burning *oleoresins of ginger and capsicum* produce satisfaction in such varied articles as ginger ale, ginger beer, candied ginger, and tabasco sauce. *Pepperiness* is appreciated in a wide variety of cooked articles. Other *spices* are important in candy flavors, medicinals, pickles, and preserved meats. Sausages and all the popular prepared meats depend very much for flavor upon spices and upon such herbs as marjoram and sage.

The cooling substance *menthol* is responsible for the "refreshing" effect of many toiletries, including tooth pastes, shaving creams, and face lotions; it is an important part of the peppermint flavor of chewing gum, candy "mints," and cough drops.

The *aldehydes* as a class seem to be able to elicit a pleasing amount of pain in flavors. The acetaldehyde of sherry flavor, the cinnamic aldehyde of cassia and cinnamon, the benzaldehyde of cherry and almond flavors, the citral of lemons, and the C-10 aldehyde and other aldehydes of orange are examples. (Some pain also comes from the terpenes present in many oils.)

The *phenols* as a class, including oils of wintergreen and cloves and such substances as thymol, carvacrol, and vanillin, have a marked numbing action in the mouth. Many other aromatic substances (in the chemical sense), including oils of sassafras, cassia, and bitter almonds, also have some numbing action.

Several of the *amino acids* and their derivatives have flavor significance. Sodium glutamate is used to impart chicken flavor. Methionine, while very sparingly soluble in water, imparts much of the rich, mouth-filling flavor of Roquefort cheese. Leucine has a weak meaty taste plus a musty odor. Glycine and, to a less notable degree, alanine and oxyproline have sweet tastes and produce cool feeling. When some of these amino acids, especially methionine and cysteine, are heated, they provide powerful pyrogenic flavors.

Diacetyl is a very important ingredient in the flavors of such various items as butter, cheese, butterscotch, honey, coffee, tobacco smoke, maple sirup, and beer. It captures immediate attention by its mild but penetrating aroma and holds interest by its pseudo sourness of taste.

Distilled oil of limes creates a thrill in the throat which is prominent in ginger ale, the kola beverages, and in some lemon-and-lime drinks. The citral of both lemons and limes, on aging, produces a similar attractive effect.

Chapter 7

Essential Oils of Flavor Interest

AN "ESSENTIAL" oil is the odoriferous volatile constituent of a plant; it is the source of the aroma. Essential oils are important sources of flavor to the food technologist. In general, they are "oily" with respect to their not being miscible with water. However, while most essential oils are soluble to the extent of only a few hundredths of 1 per cent, nearly all are sufficiently soluble in water to give it pronounced flavor. Most fresh volatile oils evaporate cleanly from paper and other surfaces, leaving no residues. Older specimens, however, may have oxidized in part to sticky, resinous substances that are nonvolatile. Essential oils are chemically as well as physically different from the relatively odorless nonvolatile or so-called "fixed" vegetable oils and animal fats which are used for food and soapmaking. The fixed oils are glycerides of the fatty acids, whereas the volatile or essential oils may be hydrocarbons, ethers, esters, aldehydes, etc.; in fact, almost anything except the glyceride esters. The outstanding point of interest in essential oils from the flavor standpoint is that they constitute strong and convenient sources of aroma for use in flavoring.

Essential oils contain a variety of types of organic chemicals, though the latter contain but five chemical elements: carbon, hydrogen, oxygen, nitrogen, and sulfur. Usually, essential oils are complex mixtures, containing sizable amounts of one to a dozen ingredients and usually traces of many more. These traces may be, and often are, of great strength and importance in the odor of the oil, and in

exceptional instances they may even dominate the odor. Among the citrus oils and some others, a large proportion—occasionally 90 per cent or more of the oil—consists of relatively odorless hydrocarbons, called "terpenes," which are less stable than the rest of the oil, tending to oxidize to poor-tasting and sticky masses on exposure to air. While these terpenes do contribute something to the normal odor of the oil, it has become rather general practice to remove them for food and beverage uses. The resulting so-called "terpeneless" oils secured thereby have fivefold or even tenfold concentrations of the nonterpene ingredients. These terpeneless oils are more stable than the complete oils, both alone and in beverages. They have smooth "round" flavors, but lack some of the verve and individuality which are characteristic of the fruits and leaves.

The essential oils are generally concentrated in special cells in the plant or in its parts. An interesting stunt may be carried out to demonstrate that oils of lemon, orange, or grapefruit are present in cells in the skin. Sharply flex the fruit skins near a lighted candle or match flame; as a cell bursts toward the flame, the mist of oily droplets released may catch fire and burn with a flash. The quantity of oils obtainable from lemons and oranges may be as much as 1 per cent. Caraway seeds yield up to 7 per cent, while rose petals yield only 0.02 per cent. Extraction of the oil may be carried out in several ways: by squeezing and collecting the mist in a sponge; by distillation with steam; or by extraction with volatile solvents like gasoline, which are afterward removed. An older process, called *enfleurage*, wherein flower petals or plant leaves gave up their oils to a fat coating on glass plates, is now used but rarely.

The oils described below are those that are now commonly in use, as the natural ingredients of foods and beverages, or those that might occasionally be used. The compositions of most essential oils are known but imperfectly, although a few flower oils, including rose, violet, lilac, and jasmine, have been the objects of much research.

Table 2.—Outstanding Characteristics of Food Essential Oils

Oil	Description of odor	Specific taste	Important constituents
Calamus	Spicy, camphoric	Bitter	Esters, camphors, aldehydes
Garlic	Pungent, sulfury	Biting	Diallyl disulfide and other sulfur compounds
Leek	Pungent, sulfury	Biting	Vinyl sulfide, mercaptan, aldehyde
Onion	Pungent, lachrymatory	Biting	Sulfur compounds and trace of allyl aldehyde
Orris	Fragrant, violetlike	....	Irone
Ginger	Pungent, spicy, fragrant	Burning	Zingerone, citral, *d*-borneol
Cardamom	Fragrant, camphoric, spicy	Burning	Cineole, camphor, borneol, terpineol
Pepper	Pungent, piney	Burning	Terpenes, camphor
Cubebs	Mild, piney	....	Terpenes, cubeb camphor
Hops	Fragrant, spicy, ethereal	....	Caryophyllene, myrcene, esters, acids
Star anise	"Licorice" to most people	Sweet	90% anethole, terpenes
Nutmeg	Spicy, turpentinic, lemony	Bitter	Terpenes, terpene alcohols, eugenol, isoeugenol, esters, aldehydes
Cinnamon (bark)	Cinnamon	Sweet	85% cinnamic aldehyde
Cassia (bark)	Cinnamon	Sweet	70–85% cinnamic aldehyde
Sassafras	Fragrant, spicy	....	80% safrole
Mustard	Pungent, lachrymatory	Biting	Chiefly allyl isothiocyanate
Water cress	Pungent, mustardlike	Biting	Chiefly phenylethylene isothiocyanate
Rose	Fragrant, flowery	....	Geraniol, citronellal, eugenol, phenylethyl alcohol
Bitter almond	Peach kernels	....	Benzaldehyde, prussic acid, a nitrile
Cherry stones	Sharper than peach kernels	....	Benzaldehyde, prussic acid
Apple (skin)	Fragrance of apples	....	Acetaldehyde, amyl esters
Peach (skin)	Fragrance of peaches	....	Acetaldehyde, methyl esters, linaloöl, aldehyde
Bergamot	Light, fragrant, estery, lemony	....	Linalyl acetate

Table 2.—Outstanding Characteristics of Food Essential Oils.—(Continued)

Oil	Description of odor	Specific taste	Important constituents
Lime (skin)	Lemony	....	Citral and 4 other aldehydes, dipentene
Lemon	Lemony	....	4 to 5% citral (90% dipentene)
Orange (sweet)	Orangey	....	Linalyl esters, terpineol, *n*-decyl aldehyde (95% dipentene)
Tangerine	Orangey	....	1% methyl methyl-anthranilate, aldehydes, esters (95% dipentene)
Grapefruit	Perfumy	....	3–5% citral, linaloöl, esters (90% dipentene)
Neroli (orange blossoms)	Rich, honeysucklelike	....	Esters, including methyl anthranilate, linalyl acetate
Petitgrain	Like neroli, but cruder	....	Esters, including linalyl acetate, dipentene
Violet	Smooth, mild, spicy	....	Irone, esters, nonadiene (2,6)-al-1
Cloves	Fragrant, spicy, pungent	Numbing	About 85% eugenol
Eucalyptus	Great variety of types	....	Great variety of constituents
Coriander	Lavenderlike	....	Linaloöl
Cumin	Buglike, spicy	....	30–40% cuminic aldehyde
Celery (seed)	Celery	....	Sedanonic lactone, dipentene
Parsley	Between nutmeg and celery	....	Apiole
Caraway	Distinctive caraway	....	50% carvone, dipentene
Anise (true)	"Licorice" to most people	Sweet	80–90% anethole, aldehydes
Dill	Like caraway	....	Carvone, dipentene, dill apiole
Fennel	Similar to anise	Sweet	80–90% anethole, fenchone
Lovage	Similar to celery	....	Apparently not investigated
Angelica (root)	Pungent, spicy, herbaceous	....	Lactones and terpenes

Table 2.—Outstanding Characteristics of Food Essential Oils.—(Continued)

Oil	Description of odor	Specific taste	Important constituents
Parsnip	Distinctive parsnip	....	Octyl butyrate and other esters
Carrot (seed)	Warm	....	Analysis not satisfactory
Wintergreen	Very fragrant ester	Sweet	99% methyl salicylate
Jasmine	Pungently fragrant, lemony	....	Benzyl acetate, linalyl acetate, jasmone, indole, benzyl alcohol, etc.
Catmint (catnip)	Camphoric, minty	....	Menthone, a lactone, dipentene
Sage	Spicy, herbaceous	....	Camphor, cineole, terpenes
Clary sage	Muscatel flavor for wine	....	Not well determined
Sweet basil	Minty, bay-rum like	....	Linaloöl, eugenol, methyl chavicol, cineole
Marjoram	Lavenderlike	....	Terpineol, esters, terpenes
Thyme	Spicy, phenolic, herbaceous	....	50–70% carvacrol
Peppermint	Pungent, cooling, "minty"	Cool	Menthol, menthone, esters
Spearmint	Crude, "minty"	....	60–70% carvone, perillyl acetate, terpene alcohols
Wormwood	Tansylike, "weedy"	....	Thujyl alcohol, thujone
Tarragon (estragon)	Suggestive of anise	....	Methyl chavicol, terpenes

Fruit and herb oils other than peppermint have usually been studied only enough to identify the principal ingredients or those responsible for the distinctive flavor. The first fruit-flavor component identified was amyl acetate, in bananas. This work was done by Kleber, in 1913. Power and Chesnut, of the United States Department of Agriculture, analyzed apple and peach oils in 1920–1922 and found acetaldehyde prominently present in addition to a group of esters. Imitation fruit and spice oils, for use in hard candy and in other products where the real fruit flavor cannot be used, reproduce the flavors more or less but frequently are composed of entirely different ingredients from those in the

Chapter 8

Volatility as a Property of Odoriferous Substances

EACH odoriferous substance has chemical and physical properties which influence its use in food. Very important among these properties is volatility. Certain odor-bearing substances, including diacetyl, ethyl acetate, and acetaldehyde, are exceedingly volatile and are lost rapidly when the substance containing them is exposed to evaporation. Aromatic substances such as the citral of lemons and the carvone of dill oil are only moderately volatile, whereas still other aromatics including the vanillin of vanilla, coumarin, and oils of parsley, clary sage, and angelica are very slow to evaporate.

Table 3 presents many chemical substances, some present in food flavors, some of interest in perfumery, and others valuable as reference chemicals. These are arranged in fourteen convenient groups, according to volatility. The vapor pressure of each pure, freshly distilled substance in Class *A* is between 1.0 and 3.1 mm. at 20°C. (68°F.), that of each substance in Class *B* is between 0.56 and 1.00 mm., to Class *N* the substances of which have less than 0.001 mm. vapor pressure. (Old, extracted, expressed, or partly oxidized oils or chemicals tend to contain nonvolatile residuals.) This table, originally devised for perfumers' use, is arranged so that a jump of four classes makes a tenfold difference in volatility and eight classes a hundredfold difference; yet within any class (except *A* and *N*) the

maximum "spread" within a group is only as 10 is to 18. Boiling points, in degrees centigrade, are given for each class. They are applicable to all the important chemical types represented except the acids and the alcohols, which have considerably lower vapor pressures for the same boiling points than have most other chemical types, such as aldehydes, esters, phenols, and hydrocarbons.

If a mixture of substances of, say, Classes *E* and *K* are exposed so that evaporation takes place, practically all of the *E*'s will have disappeared before many of the *K*'s are gone. The difference of even one class is noticeable if approximately equal quantities of *E* and *F*, for example, are evaporated. However, if 10 parts of an *E* substance is mixed with 1 part of an *F* substance, even though the *E* evaporates specifically the faster, the small quantity of *F* may virtually disappear before the bulk of the *E* is gone. The wider apart are the classes between ingredients present, the cleaner cut should be the separation when the mixture is boiled or evaporated and the less dependent should this separation be upon the relative proportions of ingredients present.

One might set up a definition of a "blend" as a mixture of substances within the same volatility class. Blends will have approximately uniform vapor concentration during the entire evaporation period, and to that extent should act as single substances. It is even possible to "fool the nose" with some blends, where the several ingredients present have the same volatility and where all the ingredients have essentially the same solubility in water and in lymph. The very discriminating smell mechanism of the nose then has no means wherewith to analyze the situation and discern that admixture is present.

In foods there may be chemical reasons as well as vapor pressure to affect the volatility of flavoring ingredients. For instance, the odor of acids tends to disappear in the presence of alkalies, whatever the evaporating conditions may be. Basic odors tend to be held by acids; for example,

fishy odors by lemon juice. Esters may be destroyed by hydrolysis if much heat is applied, and other chemical reactions may occur, especially when aldehydes are present. Odors tend to be retained rather tenaciously by any fats or oils present.

Evaporation of volatile oils from foods is always simultaneous with evaporation of water; that is, it is "steam-

FIG. 10.—Oil spots on paper, showing method of obtaining rate of evaporation. (*Laboratories of Arthur D. Little, Inc.*)

distillation." As moisture evaporates, aromatic material tends to evaporate with it; the higher the vapor pressure, the faster the evaporation. It is therefore imperative that drying out be prevented if aromatic flavor is to be retained. To conserve aroma, one should cook for a minimum of time, with covers tight, and serve the food immediately. If driving off the aroma is desired, one may cook slowly, without covers, and hold the food warm, exposed to the air for some time before serving. Freshly dug carrots, as an example, may be preserved "cold pack" in hermeti-

Table 3.—Chemicals Arranged According to Volatility at 20°C.

Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*
Class *A* 1.0–3.1 mm.	Aniline	174–196
	Benzonitrile	
	Cineole	
	Cymene	
	o-Dichlorobenzene	
	p-Dichlorobenzene	
	Dichloroethyl ether	
	Dipentene	
	Ethyl heptoate	
	Hexyl methyl ketone	
	d-Limonene	
	Phellandrene	
	Phenol	
Class *B* 0.56–1.0 mm.	Acetophenone	196–207
	Aldehyde C-8 (caprylic aldehyde)	
	Benzaldehyde	
	Butyric acid	
	p-Cresyl methyl ether	
	Cyclohexanol	
	Methyl benzoate	
	Phenylacetic aldehyde	
	Thujone	
Class *C* 0.31–0.56 mm.	Benzyl acetate	207–217
	Citronellal	
	m-Cresol	
	p-Cresyl acetate	
	Ethyl benzoate	
	Guaiacol	
	Hydroquinone dimethyl ether	
	Isovaleric acid	
	Menthone	
	Methyl chavicol	
	Naphthalene	
	Nitrobenzene	
	Octyl acetate	
	Octyl methyl ketone	
	Phenyl acetonitrile	
	Propiophenone	
	Salicylaldehyde	
	Styralyl acetate	
	p-Tolylaldehyde	
	Estragon (tarragon) oil	
Class *D* 0.18–0.31 mm.	Aldehyde C-9	217–228
	Bornyl acetate	
	Bromostyrene	
	Ethyl pelargonate (ethyl nonylate)	
	Ethyl phenylacetate	
	Isobornyl acetate	
	Isopulegyl acetate	
	Linalyl acetate	
	l-Menthyl acetate	
	Methyl acetophenone	
	Methyl heptine carbonate	
	Methyl salicylate	
	Pulegone	
	p-Tolyl acetate	
	n-Valeric acid	
	Lavender oil	
	Pine-needle oil	

* Alcohols and acids with the same ranges of vapor pressures have much lower boiling points.

Table 3.—Chemicals Arranged According to Volatility at 20°C.—(Continued)

Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*
Class *D*	Spike-lavender oil	
	Spruce-needle oil	
	Wintergreen oil	
Class *E*	Alcohol C-8	228–238
0.10–	Benzyl alcohol	
0.18 mm.	Benzyl propionate	
	Butyl benzoate (iso)	
	Camphor	
	n-Caproic acid	
	Carvone	
	Cuminic aldehyde	
	Dimethyl acetophenone	
	Dimethyl benzyl carbinol	
	Ethyl salicylate	
	Fenchyl alcohol	
	Linaloöl	
	Menthol	
	p-Nitrotoluene	
	Nonyl methyl ketone	
	Phenylacetaldehyde dimethyl acetal	
	(Hyacylene)	
	Piperitone	
	Safrole	
	Terpinyl acetate	
	Thymol	
	Bois de rose oil	
	Caraway oil	
	Coriander oil	
	Dill oil	
	Peppermint oil	
	Sassafras oil	
	Spearmint oil	
Class *F*	Alcohol C-9	238–248
0.056–	Aldehyde C-10 (*n*-decylic aldehyde)	
0.10 mm.	Anethole	
	Borneol	
	Butyl phenylacetate (iso)	
	Caryophyllene	
	Carvacrol	
	Catechyl monoethyl ether	
	Citral	
	Citronellyl acetate	
	Cuminic alcohol	
	Geranyl acetate	
	Heliotropine (piperonal)	
	n-Heptylic acid	
	Isoborneol	
	Isopulegol	
	Linalyl propionate	
	Phenylethyl alcohol	
	Phenylethyl propionate	
	Phenylpropyl aldehyde	
	Rhodinyl acetate	
	Anise oil	
	Star anise oil	
	Thyme oil	
Class *G*	Aldehyde C-11	248–259

* Alcohols and acids with the same ranges of vapor pressures have much lower boiling points.

Table 3.—Chemicals Arranged According to Volatility at 20°C.—(Continued)

Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*	Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*
Class *G* 0.031–0.056 mm.	Anisic aldehyde (aubepine) Benzyl butyrate Biphenyl Citronellol Dimethyl anthranilate Eugenol Eugenyl methyl ether Geranyl propionate α-Ionone Isosafrole Linalyl butyrate *p*-Methoxyacetophenone Rhodinol Terpineol Terpinyl propionate Clove oil Copaiba oil			Cinnamyl acetate Diphenylmethane Geraniol β-Ionone Hydroxycitronellal dimethyl acetal (Mugol) Indole Isoeugenol Isoeugenyl methyl ether Methyl anisate Methyl anthranilate Methyl cinnamate Methyl ionone Perillyl alcohol Phenylacetic acid Phenylpropyl alcohol Terpinyl butyrate Cassia oil Cedarwood oil Geranium oil	
Class *H* 0.018–0.031 mm.	Alcohol C-10 Aldehyde C-12 (methyl nonyl acetaldehyde) Amyl benzoate (iso) Benzylidene acetone *n*-Caprylic acid Cedrene Cinnamic aldehyde	259–269	Class *I* 0.010–0.018 mm.	Alcohol C-11 Aldehyde C-12 (lauryl aldehyde) Amyl salicylate (iso) *n*-Butyl salicylate Cadinene Ethyl anisate Ethyl cinnamate Geranyl butyrate Hydroxycitronellal	269–280

* Alcohols and acids with the same ranges of vapor pressures have much lower boiling points.

Table 3.—Chemicals Arranged According to Volatility at 20°C.—(Continued)

Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*	Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*
Class *I*	Jasmone β-Naphthyl methyl ether (yara-yara) Skatole			*o*-Hydroxy diphenyl Naphthyl methyl ketone Pseudoaldehyde 14 (peach) Vanillin Celery-seed oil Clary sage oil Parsley oil Patchouli oil	
Class *J* 0.0056–0.010 mm.	Alcohol C-12 (lauryl alcohol) Aceteugenol Anisic alcohol Benzoic acid *p*-Chlordiphenyl Cinnamyl alcohol Coumarin Cyclamen aldehyde (Alpine violet) Dibenzyl Dibenzyl ether Myristic aldehyde β-Naphthol β-Naphthyl ethyl ether (Nerolin) Pseudoaldehyde 16 (strawberry)	280–290	Class *L* 0.0018–0.0031 mm.	Benzophenone Cinnamic acid Diphenylamine Diethyl phthalate Ethyl sebacate Ethyl vanillin (Bourbonal) Geranyl tiglate Labdanum 6-Methyl coumarin Zingiberol	300–311
Class *K* 0.0031–0.0056 mm.	α-Amyl cinnamic aldehyde Apiole Dimethyl phthalate Ethyl citrate Ethyl myristate *n*-Hexyl salicylate	290–300	Class *M* 0.0010–0.0018 mm.	Benzyl benzoate Benzyl phenylacetate Benzyl salicylate Cedrol *p*-Cresyl phenylacetate Isobornyl salicylate Linalyl phenylacetate	311–321

* Alcohols and acids with the same ranges of vapor pressures have much lower boiling points.

Table 3.—Chemicals Arranged According to Volatility at 20°C.—(Continued)

Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*	Vapor pressure at 20°C. (68°F.)	Chemical	Approximate boiling points for hydrocarbons and most esters, aldehydes and ketones*
Class *M*	Phenyl phenylacetate Phenyl salicylate (salol) Santalol Santalyl phenylacetate Costus oil Sandalwood oil Vetiver oil			Cyclopentadecanone Dibutyl phthalate Exaltone Isoeugenyl phenylacetate Musk ambrette Musk ketone Musk xylol β-Naphthyl salicylate Phenylethyl phenylacetate Phenylethyl salicylate	
Class *N* Less than 0.0010 mm.	Astrotone Benzyl cinnamate Benzyl isoeugenol Benzyl ketone Benzyl succinate	Over 321			

* Alcohols and acids with the same ranges of vapor pressures have much lower boiling points.

cally sealed jars, or they may be boiled in a saucepan till soft and then be "hot-packed." Those treated in the first way will be found to possess much of the distinctively carrot aroma, while those treated by the latter process will have been rendered relatively inodorous.

Tables 3 and 4 may be found useful in many ways in the laboratory. With their aid the approximate boiling point of an unknown liquid may be determined by a simple evaporation test. A group of substances with similar boiling points may then be selected for a second direct evaporation comparison. Frequently the unknown substance may be identified by its evaporation speed and odor, both of which are determined by this direct comparison with other indicated substances. Evaporation tests

are conveniently made by allowing one drop of the liquid to spread on a 4-in. square of bond typewriter paper, evaporating to the point that the greasy stain, which makes the paper transparent temporarily, will just vanish. The paper should be hung up in still air in a room at about 70°F. Evaporation will be faster in a draft or in warmer air. Substances may be selected from Table 3, which will have any desired degree of lasting power on evaporation, and mixtures may be made that will evaporate simultaneously or in succession, as desired.

Table 4.—Evaporation Time for Substances Held on Paper

	Approximate Average Evaporation Time (in Hours) for Each Volatility Class of Table 3*
A	0.5 (or less)
B	0.9
C	1.6
D	2.8
E	5
F	9
G	16
H	28
I	50
J	90
K	160
L	280
M	500
N	900 and over

* One drop on bond paper, in still air at 70°F.

Chapter 9

Influences of Processing on Flavor

PROCESSING may be defined for present purposes as all operations, physical and chemical, that are performed on raw foods preparatory to their immediate consumption or their storage. Apparently, every operation from field to container has some influence on flavor, if only on the tactile element of consistency or texture.

Fruits of a limited class, notably pears, papayas, melons, and bananas and also to some extent pineapples, strawberries, and tomatoes, are preferably picked somewhat green to complete their flavor development in storage or during shipment. If pears and bananas, especially, are allowed to ripen fully on the plant, the texture usually becomes soft or even salvy before the flavor has completely developed. If these are picked while firm, though of full size, flavor production then outstrips textural deterioration. Celery is commonly boarded up to blanch the color and to mellow the flavor. The outside leaves of cauliflower, endive, and some other vegetables are tied over the edible portion for this same purpose, and rhubarb and chicory are stored as roots to produce in time tender sprouts of delicate flavor. Parsnips are frequently left in the ground during the winter so that when dug in the spring they will be extrasweet but otherwise mild in flavor.

Processing by heat does a variety of things to flavor. Plain boiling tends to drive off the volatile flavors, espe-

cially in carrots, parsley, celery, onions, and many other vegetables which, if boiled to an undesirable extent, may approach the condition of insipidity. Boiling does not need to be brisk to dearomatize. Many vegetables should be cooked for as brief a period as will produce tender texture and served without delay. In canning vegetables of this type, blanching should be brief and the principal heating should be done in the closed jars or cans.

When fruit juices are boiled, at atmospheric pressure or at reduced pressure, there is always loss of much of the original aroma. Sometimes this loss occurs early in the evaporation, as with apples. Much of the aroma condenses with the "first runnings" and may be returned with great improvement to the concentrated apple juice. Since the aromatic apple flavor is not wanted in the apple sirup used as a moistening agent in tobacco, the plain concentrated juice is used. However, for table use, apple sirup is greatly improved by having the aroma returned. Recently, the Eastern Regional Laboratory has succeeded in producing a finely flavored apple sirup, which on dilution with water yields an excellent apple juice.

Evaporation from the frozen state in a vacuum does not prevent loss of aroma, for the process is a "steam-distillation" one, even though the temperature be below 30°F. Aroma evaporation bears nearly the same relation to water evaporation at low temperatures as it does at higher temperatures.

Some fruit juices can be concentrated severalfold without loss of aroma by the physical removal of water by freezing. Machinery has been developed for carrying out the slow freezing and the separation of ice and sirup, with a minimum of loss. This process is useful for the concentration of the juices of strawberries and other fruits, the flavors of which are entirely changed on even gentle heating.

Boiling may produce new flavors, as, for example, with prunes, apples, strawberries, and cabbage. Long boiling of bones and meat is needed to yield high-flavored soup

stock, which depends on both taste and aroma for its flavor. The sweet and burnt character of coffee, chocolate, popcorn, peanuts, and caramel and the toasty flavor of the crusts of bread, cake, and pastries and of the browned surfaces of fried and roasted meats are examples of new flavors developed by heating to high temperatures. The interiors of roasts of meat or loaves of bread have relatively slight color and flavor since the temperature therein cannot exceed the boiling point of water (212°F.) until all moisture has been driven out and a bone-dry interior produced, a condition quite foreign to good cookery. Generally, the roasting of meat is completed by the time the inside temperature has reached 160 to 180°F., even though the roasting be done in a "350 oven."

Hydrogen-ion concentration has an important influence on the color and flavor of many articles that are cooked as a step in their preparation. An equivalent expression is that pH plays an important role in determining appearance and flavor during the boiling or baking of many articles. A slight alkalinity helps to retain the green color, shorten the cooking time, and keep the fresh taste of green peas, beans, and spinach. If the juice is saved for use in gravies or soups, there need be no net loss in vitamins because of the trace of soda or other form of alkali used, although many opinions to the contrary have been expressed on this subject. In general, a trace of either acid or alkali is advantageous in making cereals cook quicker than they do in plain water, but care must be taken that not enough of either is used to cause off-flavors or astringency.

Cakes, cookies, and other baked goods are greatly influenced by the pH of the dough or batter. If the pH is too high, the alkali tends to cancel the effect of added flavors, to develop a coarse brown-bread taste, and to cause extra browning for the same cooking time. When the pH is low, cooking time is increased and sourish astringency may result. Fortunately, the buffering action of flour, egg whites, and other proteins helps to stabilize the pH,

so that good flavoring is not too difficult under ordinary circumstances.

Dehydration of raw foods is generally attended by loss of a large proportion of the aroma. A considerable part of any essential oil present steam-distills out with the water during the drying. Even if heat did no damage, if no enzymes remained to cause slow spoilage, if oxidation were negligible, and if rehydration were perfectly performed, dehydrated foods as a class should be expected to be low in flavor. Even such aroma as survives dehydration may be lost later through enzyme action, unless the original blanching is done well. Peroxidases have even been claimed to "resurrect" and cause spoilage in dried turnips and cabbages. Milk and eggs are products inherently suitable for dehydration, since they have but little aroma to lose during the drying. Many cooked foods, for the same reason, will no doubt make good dehydrated items. Milk must be heated before dehydration to destroy enzymes, preferably by the flash pasteurization method, for a few seconds at a very high temperature, followed by rapid cooling. Even this short exposure produces some cooked taste. In former times, eggs were separated into whites and yolks and each part was dried separately, the yolks directly and the whites after "fermentation." Dried whole eggs have lately been produced, but the stability of the flavor still leaves something to be desired.

Fermentation may have a strong creative influence on flavor. When, by the action of yeast, the sugars of grape juice are transformed to wine, not only are ethyl and other alcohols produced but also some acids and aldehydes. These latter compounds interact with the alcohols to produce esters of high aroma value. The fermentations of beer, sauerkraut, butter, and cheese and, to a lesser degree, of pickles produce flavor. The slight fermentation of apple juice to sweet cider and the more odoriferous one from cider to vinegar are other instances of flavor building through fermentation.

Churning, precipitation by rennet, separation by centrifuging, and homogenizing are operations that produce textural changes in the product, as do milling, whipping, and other mechanical processings. Since these operations are carried out in containers, there may be minor contamination by the metals or by the wood thereof

The intense flavor-giving influence of the smoking of meats, fish, yeast, and poultry is chiefly due to the absorption of phenolic ingredients from the smoke as an added flavoring.

While articles are being cooked, they are emitting vapors and have the minimum tendency to absorb odors from other articles. It is usually safe to cook a variety of substances in vessels placed in close proximity. While cooling down, however, and especially on approaching coolness, the vessels must be kept separate, since absorption of odors may then take place from one food to the other.

Chapter 10

Flavor Changes in Storage

DURING storage, foods are exposed for more or less protracted periods of time to chemical influences within and without, and every change that occurs is likely to influence flavor. The influences from within include the life processes of raw fruits and vegetables, enzyme action in improperly processed foods, and nonliving chemical changes typified by the sugar-protein reaction and ester formation during the aging of liquors. The chemical influences from without are those of the environment. They include atmospheric oxygen, moisture, the substance of the containers, and odors foreign to the article. Over and above these inside and outside chemical factors, there are physical forces including heat, light, and sometimes vibration. There is lastly the influence of time itself in allowing slow diffusions, blendings, and "mellowings" to occur, often by reproportionation; for instance, by the interchange of radicals among esters.

Raw vegetables and fruits are living, respiring organisms, and even in cold storage they are by no means in suspended animation. In storage, they constantly change in flavor, generally in the direction of deterioration. When apples, for example, have been kept too long, there is a loss in flavor that has been poetically ascribed to their "going to sleep." More realistically, this condition should be called "moribund," the last stage before death and rotting. Both flavor and nutrition value of fruits and vegetables are greatly affected by the different stages in their life cycles.

Storage temperature has important influence on flavor. Citrus fruits develop unpleasant flavor when they are held at temperatures much under 50°F., for at low temperatures flavor production is outstripped by flavor changes, principally of an unfavorable nature. If potatoes are held for long below 40°F., much of their starch will be transformed to sugar and their flavor will become noticeably sweet.

Eggs are stored at low temperature and high humidity in order to keep them well and to prevent excessive loss of

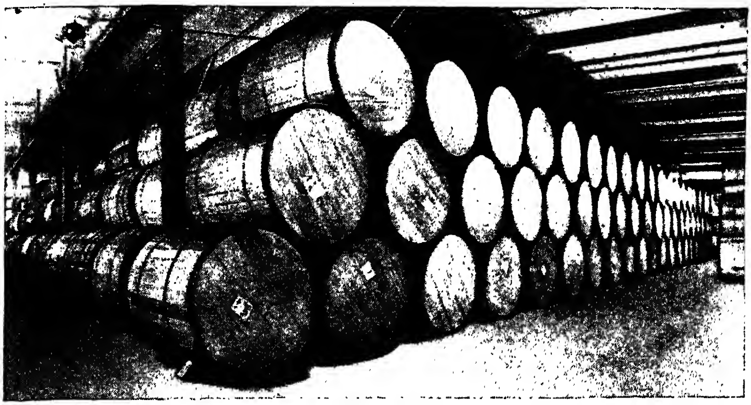


Fig. 11.—Tobacco for cigarettes is aged for two to four years in huge wooden casks to allow it to mellow and to develop a fine aroma. (*Courtesy of Liggett & Meyers Tobacco Company.*)

moisture. Care has to be taken that no flavor is absorbed from the spacers or from any mold that may develop. Ozonization of the air is sometimes permissible in egg storage for the suppression of mold.

Beef is commonly stored at just above freezing for several weeks before sale. During this time the enzymes present attack connective tissue and thereby produce tenderness. A process has been developed recently to shorten this time materially. The beef is stored at temperatures as high as 60°F., and surface molding is prevented by the fungicidal action of ultraviolet radiation.

A strictly chemical reaction, apart from enzymes, namely the sugar-protein reaction, occurs rather generally

in the keeping of foods, and it has a profound influence on color, solubility, and flavor. Any *reducing sugar* present reacts with any amino acid or protein to cause the development of a brown color ("melanoid" formation), the loss of solubility of the protein, and the production of burnt

FIG. 12.—Inspection of color of liquors aged in the wood. (*H. Armstrong Roberts.*)

aroma and caramellike taste. This reaction proceeds more rapidly as the temperature increases from the freezing zone upward. The sugar-protein reaction has become more or less classic in the case of "powdered" eggs, where the evolution of hydrogen sulfide, in addition to the other changes enumerated above, causes early and severe flavor damage. In eggs, the reacting sugar is dextrose, which is

present in considerable amount in the whites. Dextrose must not be used in the sugar curing of ham or bacon if the sugar-protein reaction is to be avoided. Ordinary sucrose, however, is safe for such use except under strongly acid conditions where inversion may occur.

In the aging of liquors in wooden barrels, several predominantly favorable actions take place, which result in the development of color, flavor body, and aroma. Much soluble material is extracted from the charred-oak staves. This action contributes progressively to color and body and, over a period of time, to ester formation and other chemical changes. To some extent, also, the barrel constitutes a semipermeable membrane, which allows water to diffuse out, selectively, to concentrate the liquor appreciably. Also, it permits the entrance of oxygen to oxidize alcohol to acetaldehyde. In the case of sherry, which is stored at relatively high temperatures (so-called "baking"), enough acetaldehyde is formed to produce the distinctive sherry flavor.

Changes Due to Environment, and Their Prevention

When fats are exposed to the air on long storage, although hard-frozen, they may absorb oxygen and become rancid. If drying out occurs at the same time, rancidification proceeds the more rapidly. Protection from drying out and from oxidation is very necessary for frozen foods. Wax-paper packings do this well, but a particularly attractive protection is a tight-fitting, impervious skin used commercially on chickens and even on large cuts of meat. A coating of special air-excluding compositions has also been used to preserve valuable fruits and vegetables.

Antioxidants are substances capable of retarding the onset of oxidation of fats and oils, thereby preventing "tallowiness." Antioxidants are of practical value only for animal fats. These are nearly devoid of natural antioxidants, are responsive to antioxidants, and need such help since they have short "induction periods." Many

kinds of seeds have a plentiful supply of natural antioxidant. The antioxidant, because it has a low solubility in fat, protects the oil as long as it remains in the seed; but once the oil is separated from the seed, little of the antioxidant remains for protection. In a few instances the natural antioxidant present is sufficiently soluble in oils and fats

FIG. 13.—Two chickens, after storage for six months, in the frozen condition. The one on the left, wrapped in transparent cellulose, shows bad "freezer burn" (drying out accompanied by injury to flavor); the one on the right, wrapped tightly in Cry-O-Vac, is free from such burns. (*Courtesy of Dewey and Almy Chemical Company.*)

to provide a reserve of protection when these oils are used with other fatty materials. Wheat-germ oil is one instance of this kind and sesame oil is another. It happens that wheat germ itself spoils rapidly, but this is due to enzyme action rather than to oxidation. The oil solvent-extracted from fresh germ, which is rich in vitamin E (tocopherol), is an effective antioxidant. Oat flour contains appreciable protective material and has been sold widely as an antioxidant. Other natural antioxidants which are sufficiently

soluble in fats to be useful include guaiac resin, licorice resin, nordihydroguaiaretic acid (NDGA), and several preparations derived from flowers and leaves (in England). The esters of gallic acid, such as ethyl gallate and propyl gallate, are particularly active synthetic antioxidants. Some substances that are but slightly soluble in fats may be useful antioxidants if so placed that the fat remains saturated with them at all times. Hydroquinone, ascorbic acid (vitamin C), and isoascorbic acid are examples. Lecithin is claimed to have antioxidant value in some vegetable oils.

Sugary and starchy foods tend to mold whenever the atmosphere around them is at very high relative humidity. Molding takes place without much regard to temperature, but develops more slowly in the cold. Plenty of mold spores are generally present in the air to furnish the "seed." Dry atmosphere is an important preventive of molding. The use of propionates, especially in baked goods, is another, though now forbidden by the Food and Drug Administration, since their use tended to make some bakers less careful of sanitary matters.

If the temperature and other factors are held constant, the use of chemical preservatives will lengthen the period during which foods may be stored safely and without damage to their flavor. For cider, vinegar, and fruit juices which are acid (pH of 5 or below), 0.1 per cent additions of sodium benzoate or the newer but less favored sodium chloracetate have strong preservative value, both for composition and flavor. For brilliantly clear liquids, microscopic quantities of silver (catadyn) are a preservative. Small amounts of sulfur dioxide, added as such or as potassium or sodium metabisulfite, are useful in the preservation of dried fruits and fruit juices to prevent darkening by enzymatic oxidation. Maraschino cherries are preserved with sulfur dioxide while stored, preparatory to their being colored and flavored. Many white wines and champagnes contain noticeable amounts of this preservative. The use

of sulfur dioxide is not recommended in the preservation of beverages when any better substance or procedure can be found, for as little as ten parts per million of free sulfur dioxide may cause an irritation of the throat which is sometimes not noticeable until 10 to 30 min. after the beverage is taken.

Many foods keep well in acid solution, but usually only after they have first been sterilized or else fermented in the presence of salt. Sauerkraut and cucumber pickles are examples. The acid present may be lactic, produced by fermentation, or acetic, in the form of vinegar. A few very acid fruits, such as rhubarb and cranberries, can be preserved, even when not fermented or pasteurized and when only loosely sealed.

Canning of foods consists of a combination of cooking and sterilizing in closed containers of either glass or tinned iron, usually with some added salt or sugar. With either kind of container, the closure is an elastic seal to keep out the oxygen of the air, yeasts, and bacteria. Canned products change rapidly in flavor during the processing but, thereafter, only slowly, usually, if kept cool; when glass jars are used, they should be kept away from light, which fades the color and usually damages the flavor. When metal cans are used, special lacquers are frequently necessary to reduce the attack on the metal by the acid fruit juices and the discoloration by sulfur compounds, especially of corn. In a few instances, grapefruit for one, a slight attack of the can causes chemical reduction which prevents darkening of the product, keeping it usable for a long period. A common type of canning suitable for pectin-rich fruits is that used in the production of jellies, jams, and marmalades, which keep even without hermetic sealing.

Transfer of flavor from one unprotected article to another can occur in storage unless care is taken. Where feasible, items of strong odor should be excluded from storage rooms, the humidity should be kept high, and the air-movement as low as is consistent with other factors (except for apple

storage). Each class of articles should be kept together and separated from other classes. Aromas in the air may be picked up by moist articles quite as actively as by fatty articles. Perhaps the most active odor absorber that is kept in the household refrigerator is cream cheese, but cottage cheese, cooked cereals, and cooked vegetables also require careful coverage. Onions, boiled cabbage, and cantaloupe melons, whole or cut, are particularly active odor emitters. Cantaloupes are especially objectionable, for many of them emit amines that may contaminate water and moist objects with unfamiliar and unpleasant odor and taste.

Chapter 11

Organoleptic Technique

ACCURATE smelling and tasting are such difficult operations for many people that it appears advisable to go into detail in making suggestions how to develop or improve organoleptic technique, especially for industrial applications. Both smelling and tasting are necessary in judging food flavors, but smelling is always done first. The senses are usually amply keen and discriminating for any work one sets out to accomplish. Such difficulties as are encountered usually have to do with the concentrating on the work at hand, with making adequate comparisons between samples under examination, and with interpreting the observations in terms of the information needed. Even persons of ordinary sensitivity may become good flavor discriminators if adequately trained. Education in this respect is not usually for the purpose of increasing one's sensitivity, but rather, for training the associative functions of the mind, to enable it more quickly and accurately to report its impressions in meaningful terms.

Perhaps the most important requirement for effective sensing is complete concentration on the subject. There should be no distractions, for distractions are invariably competitive with sensing. The conditions should be natural; and the taster should be at ease, completely comfortable and in a quiet place. (It has been observed that loud noises completely prevent any smelling or tasting observations.)

In any particular session, it is best first to observe the visible characteristics such as color, clarity, or viscosity of

a liquid or the texture of a solid. This operation serves to focus the attention and to start the functioning of the faculties. Identification of the nature of the sample often accompanies the observation of the visible characteristics. As a result, the nose is ready to check on any odor present, and the operator has a tentative idea of what the sample should smell like, which may virtually act as a criterion of the odor or taste.

Smelling

Smelling is done best by inhaling strongly through the nose for a period of two or three seconds with both nostrils open, even though only one is used. In smelling an unknown specimen, it may be well first to waft a little of the aroma toward the nose and to sniff cautiously, to avoid too strong an excitation or perhaps actual temporary injury to the sense of smell. If the odor so wafted is weak, then full smelling is permissible. It is important always to smell with the same nostril or to smell with both, especially in making direct comparisons, for the air stream leading to the smelling area is rarely equal in effect for the two nostrils.

As far as possible, smelling should be done far away from the hands to avoid ever-present skin odors from interfering with judgment. The best procedure is to smell while seated at a desk or bench, with the samples arranged in front of one. Smelling can be done by bending the body forward until the nose is within about an inch from the specimen. A most convenient setup is the rotating table used by tea tasters and coffee-cuppers. The worst possible procedure is to compare two specimens, one held in the left hand and one in the right, by smelling one with the left nostril and the other with the right. Such a method violates all of the precautions noted above as important and may lead to inaccurate findings. When smelling is being done, the air should be still, even if it is odoriferous. One quickly learns to compensate for fixed or unavoidable odors.

Smelling is most accurate when one specimen is compared with a standard, which should be a simple comparison for identity, or at least for similarity, in kind and in strength. When no standard is physically present, one unconsciously compares the specimen with his mental concept of what it

FIG. 14.—Brandy taster notes aroma, using a snifter. (*Black Star Publishing Co.*)

should smell like. While this may be permissible for experienced operators (who generally are careful not to do it), it is poor practice for beginners, since self-deception may result.

There are occasions when a series of specimens similar in nature are to be intercompared. In such an instance, one smelling usually sorts out and arranges roughly, with the strongest or best at the left tapering to the weakest or the

worst at the right. Then, by careful comparison of only two at a time, the series may be arranged in order. If it takes, say, ½ min. to decide which of two specimens is the stronger or better, it may take at least 25 times this long or 12.5 min. to arrange a group of five specimens. Time and

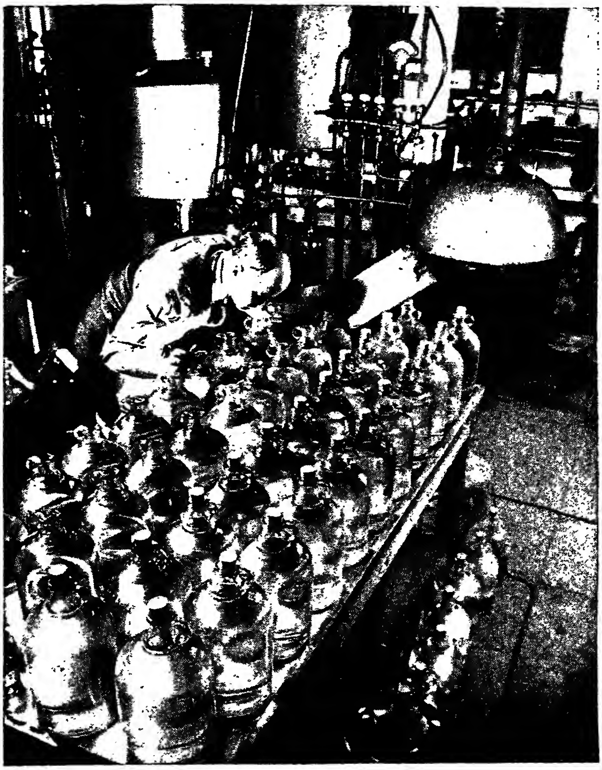


FIG. 15.—A perfumer examines the various "cuts" obtained during distillation of a synthetic odorant to determine which cuts are suitable for inclusion in the finished product. (*Courtesy of Givaudan Delawanna, Inc.*)

accuracy favor working with a small number of specimens at a time and always checking these, one against the other, until definite findings are obtained. Eight specimens in a series are as many as may be worked effectively.

The nose recovers its sensitivity fairly rapidly after it has been used for smelling, if the odor is not irritating. It is

sensitive again in perhaps five seconds for the next smelling. It is best practice to smell first the specimen and then the standard, several times in a 5-sec. rhythm, so that if the nose loses acuity during the sequence, both items will be treated equally during the gradual fading of sensitivity. Hundreds of sniffings may be done in a day without undue effort or loss of sensitivity.

FIG. 16.—Appraisal, on "blotters," of volatile flavoring agents. (*Laboratories of Arthur D. Little, Inc.*)

For adequate comparisons of odor, both specimens should be equally presented to the nose. The surface areas exposed should be about the same, and both specimens should be at the same temperature. If the specimens are in bottles, the bottles should be of the same size and equally filled. Perfumers use "blotters" for convenient and accurate odor comparisons of strongly odoriferous oils and

tinctures. These blotters are pieces of odorless, absorptive paper ½ in. wide and about 6 in. long. The papers are dipped into the respective liquids to the depth of 1 in. and the wetted areas are compared for odor. Odor impressions obtained from the smelling of blotters are subject to constant change, for the compositions vary continuously as the more volatile ingredients evaporate. A blotter test fol-

FIG. 17.—"Steaming" a piece of rubber to intensify the odor, and then smelling the released aroma. (*Laboratories of Arthur D. Little, Inc.*)

lowed along to dryness virtually makes possible a complete distillation study from the most volatile to the least volatile ingredients of the samples under test. That is the sort of study needed for perfume ingredients and for some flavoring oils, in order to make sure that they are true and pleasant at all stages. Smellings from bottles are dominated by "top notes," produced by the lowest boiling ingredients. Smellings from the stoppers are intermediate between those from blotters and those from the bottles.

In comparing lumps, sheets, or dry powders, which may have very slight odor, one may exhale on the article with the moist breath from the mouth and then note any odor as the condensed film of moisture is drying off. Frequently, this "steam distillation" will bring out odors distinctly that might not otherwise be detectable. Another procedure

FIG. 18.—Collection of odors that are evolved slowly. In this instance, water and mineral white oil, in Petri dishes, absorb the odor emitted by plastic bottle caps. (*Laboratories of Arthur D. Little, Inc.*)

suitable for pieces of rubber, felt, or similar weak-odor articles is enclosing them in an odor-clean can or jar, preferably a brand-new one for each test, and smelling the accumulated, slowly evolved odor after a period of time, such as a day. For appraising the odor of an air space, one may expose thin layers of water or of mineral white oil in flat dishes for a matter of hours and then smell the accumulated absorbed odors (in an odor-free room).

In all techniques discussed to this point, the sensitivity of the nose has been protected by using it for short sniffs only at judicious time intervals, so as not to cause fatigue. Tiring of the sense of smell may be used to advantage in rare instances, however, on the assumption that while the nose dulls to one particular odor, it may still be fairly sensitive to other odors. Therefore, if two samples differ slightly in composition and smell alike to a "fresh" nose, the nose tired by smelling one sample, when used on the other sample, may discern the small difference.

Smelling requires such minute quantities of materials to be absorbed by the membrane that only rarely does one have to consider possible injury to the body thereby. Putrid odors may upset the stomach through psychic reactions, however, until one learns to "take them in stride."

Tasting

When the smelling work is completed, one may then proceed to tasting. Tasting is slow work at best. Recovery from a tasting is a matter of minutes and the rhythm method of tasting suggested under "smelling" should be used. The tempo should be slow, say at one or two tastes each minute or even one each five minutes for very strong tastes or for thick or clinging materials. The tasting of a dozen or a score of samples may be a half-day's work for a professional taster, and these tastings are usually most valuable when made against a definite standard. With tea and other thin liquids, several hundred samples may be tasted in a day with ease.

Tasting in the strict sense is done only for sweet, sour, salty, and bitter. It always should follow smelling, which detects the aromatic ingredients that tend to intrude themselves while tasting is being done. Tea tasters, wine tasters, and other professional tasters sharply distinguish between what the nose tells them and what the tongue alone can tell them: pepperiness, coolness, astringency, and the

four true tastes: sweetness, sourness, saltiness, and bitterness. With practice, one learns to concentrate upon any one of these qualities to the virtual exclusion of the others.

Some tasters insist on a certain ritual between tastings or groups of tastings, such as nibbling on bread, crackers, or

Fig. 19.—Comparison of kola drinks by tasting. (*Laboratories of Arthur D. Little, Inc.*)

an apple, or rinsing out the mouth with water or even with absorptive charcoal and then water. Any water so used should be lukewarm. Something may be gained by these artifices, especially the rinsing with water, to remove adherent material, but the best general technique is to allow the saliva to lave the taste buds in a natural manner and thereby to prepare them for the next tasting. It is desir-

able to continue to follow a well-developed routine with all tastings, unless one wishes to revise his entire style. Smokers can be adequate smellers and tasters of strongly flavored substances, especially if they do not smoke for an hour or more before each sensing. The tendency is for smoking to dull the senses, but there is generally such an excess of sensitivity that enough may still be present even after smoking to do good work if the specified time lapse is observed. Long-time smokers usually learn to make "allowances." One should act naturally and give sensing his undivided attention while the work is going on. Moreover a great deal of thought and attention is needed at other times, to educate and discipline the powers of association and to develop acute flavor-consciousness and a broad, well stocked, and accessible flavor memory.

The preparation of samples for tasting may involve steeping or boiling to make an infusion, or merely dissolving in water. Some of the same lot of water must be used for preparing the *Standard* as was used for preparing the *Specimen*, and both solutions should be produced at the same time so that the only taste variables encountered will be the actual taste differences of the substances. Temperatures must be the same for valid comparisons, and most materials are best tasted at body temperature. Standard sips are needed—usually a teaspoonful, but sometimes a tablespoonful—for the quantitative element is important and often is what is being judged. In order not to burden the stomach with the liquids being tasted, it is good practice to spew them out after the tasting. Rinsing of the mouth usually is not necessary or desirable, except after tasting clinging substances. If smelly teaspoons are encountered, which may perhaps have been used for onion-containing soup, these spoons may be restored to usefulness by being baked for about an hour in a low oven (300°F.).

There are specialized tasting techniques used in the judgment of the flavor of bread and other baked goods or of chewing gum, where the soluble substances are introduced

into the saliva by chewing a standard-sized piece. In these instances, there is opportunity to assay the texture and the aromatic elements early in the chewing operation, and later the true taste elements of sweetness, sourness, saltiness, and bitterness, and the associated feeling of elements of warmth, coolness, pain, and touch (including astringency as well as texture).

FIG. 20.—Testing of chewing gum for flavor. (*Laboratories of Arthur D. Little, Inc.*)

When tea or coffee is being tasted, it is conventional to "slurp" the material at one stage; to suck it in noisily through pursed lips, so that the liquid is sprayed over the palate. Soups may be so tasted to advantage. Where there is undissolved material that may be a reservoir of aroma, such as tea leaves or coffee grounds, it is customary to lift the material with a spoon for smelling. Tea and

coffee tasting involve both smelling and tasting. The aroma is judged first while the infusions are hot and odoriferous; the tasting can be done to best advantage some minutes later, after the infusions have cooled and the aroma is pretty well gone. Spices are best judged critically by eye; then, after grinding, they are judged for the fineness of their aroma. The method consists of smelling a 4 per cent cold-water infusion.

Essential oils to be used for flavors are judged by a variety of tests, including the "blotter" test, the sirup test, the alcohol and water test, and the use test. In the sirup test for appraising essential oils for use in candy and beverages, a little of the oil is mixed into 65 per cent sugar sirup; phosphoric or citric acid is then added and the mixture tasted. In the alcohol and water test, one, two, or three drops of the oil (according to its strength) is dissolved in ½ oz. of alcohol, which is stirred into 7 oz. of water—frequently hot water. The cloudy suspension is judged for aroma value, and it may also be tasted. The use test may be very important, not only for essential oils but for many other ingredients; one tests the material for aroma and for taste, in normal amounts, in the beverage, dessert jelly, or other product in which it is to be used.

Strong-tasting ingredients, and their standard for comparison, are preferably diluted with an inert solid or dissolved in water to bring them down to a comfortable concentration for comparison. This procedure will result in easier tasting and will make more tastings possible in a given session. Greater accuracy of comparison will also be possible.

Comparisons are more revealing when kept as simple as possible, such as a single substance being compared with a standard of its own kind, rather than with one ingredient of a more or less well-seasoned mixture. This policy is in no way in competition with that of diluting strong-tasting materials to comfortable values, but it may be in direct competition with the use test described above. Which

policy to use may be decided upon in each instance, on its own merits, but it is perhaps best to taste according to both policies if time permits.

Example of Quantitative Organoleptic Work

A considerable degree of reproducibility may be obtained in organoleptic testing. The figures given in Table 5 were

Fig. 21.—Laboratory group scores samples of reconstituted milk. (*Laboratories of Arthur D. Little, Inc.*)

taken from typical data sheets secured from a laboratory devoted entirely to the appraisal of dairy products; they apply to milk powders that had been exposed to accelerated aging tests. The values quoted represent commercial tasting practice and demonstrate the degree of accuracy that may be attained in this kind of routine organoleptic work.

Scoring was done on a 15-point scale, with 15, 14, and 13 as excellent; 12, 11, and 10 as good; 9, 8, and 7 as fair; 6, 5, and 4 as poor; and 3, 2, and 1 as very poor. Wherever there

was any definite off-flavor, the score was 7 or below; and when milk was no longer usable, the score was below 6. By much practice, the tasters were generally able to average well within one point of the general average. All milk powders were selected for the test and reconstituted in a mechanical mixer by a person not doing the tasting and were served at about 95°F. for the tasting. The tasting was done in an established manner, without swallowing, in ¾ oz. sips, after each of which the mouth was rinsed with lukewarm water. All findings were written down secretly and scored to the nearest whole point; then the score sheets were turned over to a secretary for tabulation and averaging. On any particular day, there was always a preliminary "key-testing," to determine the fitness of the tasters; then for those found normally acute, came the day's work, of about eight tastings of eight samples each.

Table 5.—Dry Whole Milk Flavor Scores
(Initial Standards)

Date: June 14 and June 15, 1944

Key No.	Tasters												Average score
	1	2	3	4	5	6	7	8	9	10	11	Total	
1	10	11	10	9	11	10	10	9	10	11	9	110	10.0
2	4	6	4	5	6	6	5	6	5	3	6	56	5.1
3	7	9	6	6	8	8	8	11[1]	6	6	8	72	7.2
1[2]	10	11	11	11	10	8	10	9	10	11	9	110	10.0
2[2]	6	6	4	7	6	6	5	5	5	3	4	57	5.2
3[2]	8	7	6	9	8	8	9	6	7	6	7	81	7.4
4	10	9	8	10	10	10	7	7	9	9	10	99	9.0

[1] Excluded, as "wild."

[2] Keys 1, 2, and 3 same as those above.

Table 5 gives the "initial standards" showings on two consecutive days for eleven operators. The same three standards as those of the first day, plus an additional one, were used on the second day. Such duplication of keys is not usual and was not expected. It will be noted

that averages obtained were closely the same for the two days for the same samples and also that the individual tasters checked themselves reasonably well. These three (or four) samples were kept available for reference during the respective days, as standards.

Table 6.—Dry Whole Milk Flavor Scores

(Summary sheet)
Set No. 15

Date: Wed. a.m., June 7, 1944

Sample No.	Identification		Tasters					Average score
	Set	No.	A	B	C	D	E	
1	10	4	7	7	7	10	7	7.6
2	9	4	9	9	9	10	10	9.4
3	10	2	7	7	9	10	9	8.4
4	11	3	9	9	9	10	9	9.2
5	14	4	8	8	9	9	10	8.8
6	11	5	11	7	9	10	9	9.2
7	9	7	9	9	9	8	10	9.0
8	10	3	10	9	9	9	9	9.2
Deviations from the averages:								
Sample 1			− .6	− .6	− .6	+2.4	− .6	
Sample 2			− .4	− .4	− .4	+ .6	+ .6	
Sample 3			−1.4	−1.4	+ .6	+1.6	+ .6	
Sample 4			− .2	− .2	− .2	+ .8	− .2	
Sample 5			− .8	− .8	+ .2	+ .2	+1.2	
Sample 6			+1.8	−2.2	− .2	+ .8	− .2	
Sample 7			0	0	0	−1.0	+1.0	
Sample 8			+ .8	− .2	− .2	− .2	− .2	
Totals of deviations			6.0	5.8	2.4	7.6	4.6	
Ave. deviation			.75	.73	.30	.95	.58	
Algebraic sums of devs			− .80	−5.8	− .8	+5.2	+2.2	
Tasters' ave. trends			− .10	− .73	− .10	+ .65	+ .28	

Table 6 is the summary sheet for a set of eight samples tasted by five operators. Each of these samples would have to be tasted again, as parts of other sets, for there must be a minimum of ten tastings to establish the rating of any one

specimen. Two matters of interest in this table, which shows specimens mostly in the "fair" range, are the "deviations from the average" of each taster's findings and his "average deviation." In order to have his findings used on a particular day, his average deviation had to be less than 1.00 unit. A calculation shown on this sheet, used only occasionally in practice, is the algebraic sum of the deviations and the calculated tasters' trends, useful in correcting optimism or pessimism in tasting.

Chapter 12

Consumer Testing of Foods

THERE are many occasions when a manufacturer would like to know accurately how the buying public regards his product, especially whether or not it is favored over competitive articles. Has the public taste changed? Has his article slipped in some way, imperceptible to him? Is the product right? Is something wrong about the package? How can it be made to please even better? If it is now well-liked, why can't it be pushed harder for sales?

Each manufacturer will act in his own way to determine consumer interest. One may feel that his own inherent judgment is all that is needed and that sooner or later the public will confirm this judgment by enthusiastic patronage. Another may consult an expert chef for opinion. Still another may have a plant tasting panel, and the last man may turn the matter over to an organization that makes a business of obtaining consumer reactions. Which way is best?

A symposium on consumer testing, edited by Washington Platt, was published in *Food Industries*, March, 1941. If this symposium did nothing else, it brought out emphatically that consumers by and large are observant and are capable of choosing between samples skillfully presented. Moreover, this preference can be determined in a reliable way. Selected pertinent quotations from the several participants are given here for the wealth of experience expressed. The reader is referred to the original for further detail.

"Many executives of industrial concerns assume that they are in close touch with the consumer preferences for their products. Frequently this is not the case. Their manufacturing department manufactures their product according to preconceived notions. Their sales department sells not to the final users, but to dealers. Great sales effort results in a reasonable volume of sales, but sales might be much greater if some simple changes were made in the product to make it accord more closely with consumer desires. With the millions of dollars spent for advertising, it is surprising that so little is spent for finding out by direct study what the consumer really does want.

"It is still the common practice in many companies for a committee or panel of executives to inspect their own products from time to time and compare them with those of competitors. The presumption that such a committee may know what consumers prefer in a food product is often erroneous. The production man on the committee has built his own ideas into the product for so many years that even in the dark he could pick out his own creation and quite honestly vote it to be the best because it satisfied the requirements which he believed buyers wanted. For instance, he may prefer a pronounced flavor, not realizing that consumers have gradually turned to milder flavors since the time when he was a younger, more disinterested consumer. Again, the chemist is unable to disassociate consumer reactions from his chemical analyses and combinations, and may believe that the ice cream containing the highest percentage of butterfat is the one which consumers must prefer. Similarly, the operating man minimizes the importance of points of superiority in a product, especially if they necessitate a considerable increase in manufacturing expense.

"One method for the determination of the 'eating qualities' of food products is scoring by a small group of trained and experienced judges. This is a very common method as exemplified in the scoring of butter, ice cream

and bread. The technic of scoring food products has been described in detail by Platt. In using this method we assume that the conclusions of the judges are the same as those of the general body of consumers. With more or less standardized foods, such as butter, this may (or may not) be the case. With most foods we have no right to make such an assumption. To find out what the ultimate consumer likes, we must go directly to this ultimate consumer and find out what he prefers. This is called a 'consumer preference test.'

"When home use is necessary, as in testing cooking fat, salad dressing, canned soup or beans, soap, cleanser or water softener, it is preferable to make arrangements in some way other than by ringing door bells. The officers of a women's organization may sponsor the test in a preliminary announcement to members, and, with a minimum of wasted effort, the investigator may call at the homes to deliver the product and explain the required procedure. Usually compensation for making the product comparisons is unnecessary, beyond a free supply of the products being studied. The Kroger Food Foundation gives a Christmas gift to its numerous home testers in many cities. However, a small donation to the treasury of a women's organization, proportionate to the number of members completing a test, will often cause nearly a 100 per cent response within a specified time. When comparisons of an extensive nature are necessary, such as in cooking and baking, a small gift to each home may be advisable for obtaining good will and maximum results. It is worth noting that, in home tests, it is possible to obtain the opinion either of the family as a unit or of individual members—men as well as women, and children as well as grown-ups.

"The experience of General Foods Corp. and others seems to indicate that the repeated seeking of opinions about radio programs, advertising themes and product characteristics from the same consumer juries tends to develop a professional attitude in some individuals and a

careless, irritable or noncooperative mood in others. As a precaution against this, comparisons should not be requested too frequently and new groups of consumers should be brought into each test. Spontaneous reactions of amateurs reflect market preferences more accurately.

"This product-testing technic was originally developed in 1932 and has since been used to measure and point out ways of improving the competitive product position of a large number of mass-market household items. It has been used successfully for testing breads, coffees, teas, breakfast cereals, cocoa, shortenings and many other products.

"It was designed specifically to answer the following questions:

"1. How does the tested product compare in general with competing products in satisfying desires of the largest number of consumers?

"2. In what qualities or attributes has the tested product an advantage or disadvantage in relation to competing items?

"To obtain valid answers to these questions, the method has to meet the following requirements:

"*A*. The group testing should be a representative sample of the market for the test product.

"*B*. The testing group should be large enough to give significant statistical results.

"*C*. The products should be tested in 'blind' form to avoid the influence of factors not pertinent to the problem.

"*D*. The method of testing should closely approximate normal use.

"*E*. The results of the test should show:

"(*a*) How test product compares with standard in general preference.

"(*b*) In what ways the test product should be modified to improve its competitive position.

"A great deal of doubt has been expressed about taste tests. While some of it is just, the critics may be like our

friends who say they cannot use electric razors—which *also* require patience, understanding and repetitive effort! As a matter of fact, actual tests indicate that we may not give the consumer enough credit for taste intelligence, especially when she disagrees with us! Certainly all testers are not equally discriminating and some may do no more than make a guess. This and other negative factors must be offset by attention to numerous details, some of which may here be mentioned briefly:

"*a.* Continuous effort to maintain a balanced group.

"*b.* The use of a sufficient number of testers to level out peaks of prejudice or valleys of opinion.

"*c.* Careful preparation and pretesting of the questionnaire so that supplementary questions will reveal the accuracy of the main replies.

"*d.* For taste testing, the highest and lowest income groups may be omitted. These people all have fairly normal taste reactions, but the wealthy lack genuine interest and many of the poor lack the ability to fill out intelligent questionnaires.

"*e.* The committee operates in their homes under normal conditions. This avoids spot tests which force an immediate and perhaps too hasty decision, and it likewise forestalls the collaboration or influence of vote so frequently observed when testing is done in groups or en masse.

"One fundamental principle in all of these tests is that of comparison. When one product is used and the simple question is asked, 'Do you like it?' the easiest, most courteous answer is 'Yes.' If, however, a comparison with some other product is expressed or implied, more accurate results will be forthcoming.

"Better judgment as to which of two products is preferred may be obtained by asking the following three direct questions: (1) In your opinion, is there a difference between these products? (2) If so, which one do you prefer? (3) Why? The first question restrains the tendency to search for minute points of contrast and gives an

opportunity to indicate the lack of a significant difference. The second question brings out the general preference. The third invites the tester to give reasons for his choice, and in doing this he records both his favorable and unfavorable impressions. By tabulating these for all voters, the relative importance assigned by voters to the various product characteristics may be determined. For dependable results, it is important that each tester make his choice independently of others and without being influenced by them in any way. It sometimes happens that when products are being compared by a group of people, one outspoken tester may influence the decisions of others and invalidate the results by calling out, 'I like Number One. Doesn't it have a lovely color!' In order to avoid this possibility, it is often advisable to shuffle the sample numbers in such a manner as to make it practically impossible for different testers to compare their impressions.

"One of the most difficult problems is that regarding the preference for a food which is intended for daily use over a long period. Obviously, one test must consist of supplying to consumers for periods of several weeks the sample which has been tentatively selected, to see if it really 'wears well'; that is, whether they readily tire of it. Only one sample can be submitted to different groups over a period of several weeks and their comments compared in order to obtain an idea of relative preference."

Chapter 13

The Art of the Chef

THE art of cooking has had many illustrious representatives, especially of the French school, but none more noted than Auguste Escoffier, whose methods will be reviewed here for their suggestive value to food technologists. A certain degree of familiarity with this famous man and his methods is still possible through the generous cooperation of chef Camille den Dooven, who for years was assistant to and friend of Escoffier.

Auguste Escoffier was born at Villeneuve-Loubet, in the Maritime Alps of France, in 1847, and lived to the ripe age of eighty-eight. During the last fifty years of his life, he was uncontested master of French cooking. His training, and the training he gave others, consisted of apprenticeship in fine hotels. The system was to have several apprentices working on the preparation of food at each of a number of stations, under the supervision of the chef and his corps of assistants. When each boy became proficient, he was moved on to the next station, until, in ten years or more, he had mastered some of the intricacies of the culinary art. Escoffier started at the age of thirteen to work for a famous uncle at the Restaurant François at Nice, where he remained for six years. From there he went to Paris, to the Restaurant du Petit Moulin Rouge, where he worked further, under the Chef de Cuisine Ulysse Rochaud. At the age of twenty, he left for military service for his country, but, at the completion

of his enlistment, returned to cooking and became a distinguished man of skill and culture.

Escoffier's first principle was to avoid mistakes rather than to try to correct them. In a general way, this meant to start with fresh, sound materials and to make no move that was not forward. It meant that where there was a choice the most suitable material or processing should be used. For example, starch instead of flour was used for thickening, and the cooking was slow and gentle in order to burst all the grains and make a smooth texture. The cooking of milk sauces and potatoes, he believed, should not be done in aluminum kettles, lest contact with that metal injure the flavor, but rather in retinned copper, or even better, in stainless steel.

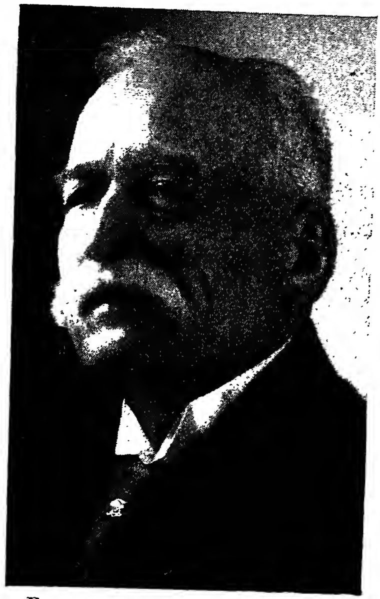


FIG. 22.—Auguste Escoffier at eighty-two, when he was awarded the Chevalier Order of the Legion of Honor by the French Government. (*Wide World Photos, Inc.*)

"Stock is everything in cooking," said Escoffier, "at least in good and well-flavored cooking. Without it, nothing can be done. If one's stock is of good flavor, what remains of the work is easy; if on the other hand, flavor is lacking or merely mediocre, it is quite hopeless to expect anything approaching a satisfactory result."

Great pains were taken in building up *neutral* bases for sauces and stocks. Long, slow simmering of scraps of meats and vegetables yielded a mild stock that was used as a base, in place of water, in making up soups and sauces. Milk was never heated to a boil, but only to gentle simmer-

For milder flavor, eggs were "hard-boiled" by gentle simmering rather than by actual boiling. When poached or fried, they were heated slowly in a thick-bottomed saucepan.

In flavoring foods, the first flavoring agent added was always *salt*, to a point judged most favorable for the product and the eater. Fine, fresh vegetables needed relatively little salting or other seasoning, whereas flatter and poorer things needed more building up.

Once the salting was done, then came other additions in a particular order found best in practice for each kind of food. No seasoning was ever added to the point that it could be noticed as such, but only to the point of bringing out the flavor of the article to which it was added. When garlic was used, it was only as a light smear on the saucepan or salad bowl—never as an addition of the bulb itself.

For vegetables, soda was used very sparingly; it was added only after the first minute of boiling, and then merely in quantity sufficient to preserve any bright-green color. Sugar and small amounts of various herbs were frequent additions. Meats were salted early in the cooking if the juice was to be drawn freely, but at the last moment if it was to be retained. Some mustard was always useful in bringing out the meat flavor, but usually very little of the strong-tasting meat sauces was used. Sauces to be served with fish were first treated with nutmeg, then with mustard, and finally with sugar to the degree needed to overcome any flatness. Dessert flavors that were weak, such as strawberry, frequently were reinforced with a little raspberry, or orange with lemon. Chocolate of high grade was never salted. Sugar was used rather freely in pastry to make for pleasing tenderness. Vanilla, which was generally used with sweets, was found to work best when first thoroughly incorporated with sugar. The blending of flavors was given much consideration, particularly in desserts. Escoffier recognized the need of a third flavor to harmonize two that did not normally go together.

Another guiding principle was that of serving flavors of gradually increasing strength during a meal. It was based on the knowledge that fine or delicate flavors cannot be appreciated fully after one has partaken of stronger flavored foods. There were many practical applications

FIG. 23.—Chef George Mardikian, of Omar Khayyam's in San Francisco, grooms his ten-year-old son, George, Jr., in the secrets of the culinary art. (*Wide World Photos, Inc.*)

of this principle in planning menus and in flavoring dishes. A cup of hot water taken before breakfast was a good preparation for the meal, which started with mild-flavored cereals and continued through eggs to fruit at the end. Dinner started with a soup of delicate flavor and worked up to a well-flavored dessert. To Escoffier, as to most

chefs, smoking or taking a cocktail before a dinner was an inexcusable vulgarism that left one unable to enjoy the fine treat that the chef had prepared. Meals for smokers or thoughtless drinkers had to be overseasoned or the diners thought them tasteless. Wine was to be enjoyed, true, but always at the end of the meal. Strong-tasting accessories, such as mint jelly, were never used during a meal where wines were to be served.

Escoffier was a man of simple personal tastes and great restraint, who lived to cater to others, to nourish them with food, and to please them with flavors. He was most cooperative and was always ready to acknowledge his debt to others. While he followed and, indeed, typified the French school of cooking, which brings out the flavors in foods, he also recognized that other systems were possible, even though he did not understand them. He had a profound respect for the Chinese school, which changed and hid the natural flavors.

Escoffier was sparing in the use of fats, keeping the welfare of the eater in mind. He objected, for instance, to the use of mayonnaise, which he considered indigestible, and to the serving of much fried food. This feeling for digestibility was one important reason for the public esteem of Escoffier. The practice by den Dooven of preserving flavor to be sure that the even more sensitive vitamins are preserved is a present-day example of the considerate type of philosophy that is natural in every good cook.

"The chef whose dishes are flavored with the touch of a real artist will experience over his saucepans emotions as poignant as those an artist-painter feels when he has completed a master painting."

Chapter 14

Beverage Appraisal by Taste

THE flavor testing of tea and coffee is commonly an appraisal step in the buying and selling of these commodities: an inspection of the goods for identity of character and for strength and condition. Most tea tasters and coffee-cuppers are either the brokers who export and import these goods or the managers or purchasing agents of large organizations. These men combine a business viewpoint with tasting skill. Wine tasters, too, are businessmen who handle a product of somewhat variable quality by a generally satisfactory system of evaluation based on sensory reactions: appearance and flavor. The flavor control of beer is in the hands of the master brewer, an executive responsible for all operations in the brewery.

A personal characteristic of most professional tasters is exceptional devotion to a work they love. Nearly all these men have come up through apprenticeship in the long, hard school of experience, for there are still no schools of tasting at the time this book is written.

The writer gratefully acknowledges the help of Robert A. Lewis of Standard Brands, Inc., and George F. Mitchell of Maxwell House, in the preparation of the section on tea tasting, and that of Cedric P. Wheelwright of La Touraine and William S. Scull II, of the William S. Scull Company, on coffee tasting. The data on the Tasting of Wine were taken from a dinner menu of the Wine and Food Society of Boston.

Tea Tasting

Tea tasting is done initially in the "country of origin," where the lots of tea are first classified, by appearance, into types; then these rough gradings are further classified, by tasting, into price grades within the types. This grading is done with a high degree of accuracy against recognized standards, which are usually average samples of each grade of the previous season, and the findings of one man very closely support those of another. The business of tea grading is a highly ethical and responsible one, and the price figures assigned by the original tasters mean much in the trade. On the arrival of the tea at the country of destination, tasting is done mostly to check the condition of the tea in individual cases against the many things that might befall it in transit or storage. The grade and price are already marked on the samples.

It has been found desirable and even necessary to use blends in all commercial brands in order to preserve individuality and uniformity throughout the years. Should one or two components vary somewhat from the type in a particular season, other teas can be substituted in part or entirely, so that the effect of any change will be negligible in the blend. This stability of flavor in blends is most favorable for building sales.

A few words about tea itself may be helpful for an understanding of the practice of the tasters. There is only one kind of tea plant, *Thea sinensis,* but from this one species many grades of tea are obtained, depending on every detail of climate, culture of the plant, and treatment of the leaf. The higher the altitude of the plantation, the finer the tea. The fertilization of the soil and other details of tea culture are matters of great importance and have made possible the distinctive quality of tea which has made some planters famous. The weather is important also, the best tea being produced by slow growth in dry, cool weather. The size of the "tip," or branchlet, picked is important, the smaller and younger leaves producing

more cups per pound and a better tea than the larger leaves picked at the same time from the same plants. The drying and fermentation which are done indoors with artificial heat determine whether the particular leaves will become green tea by drying only, oolong by partial fermentation, or black tea by full fermentation and then drying. Aroma is developed during the curing. Thus, green teas and black teas are the same kind of leaves treated differently. Cultural methods have improved greatly during the past century, so that, on the average, tea quality is improving all the time. Competition between brands also has helped greatly in lifting the quality of the average tea delivered to customers.

The dry tea is first examined for color and uniformity. *Even* or uniform-sized particles indicate careful preparation and screening. If many stems are present, the dry tea is called *stalky;* if the leaves are flat and not curled and twisted, it is called *flaky*. The color is considered important; for black teas, the uniformly brown or black leaves are preferred over those that are grayish. So important are these visible evidences of quality to the taster that he may be said to do his first tasting with his eyes.

For tasting by the English method, the tea is brewed in porcelain pots, in the amount of 200 cups to the pound of tea, after pouring actively boiling water on the leaves. The brewing is done for just six minutes. Then the tea is poured into porcelain cups, and the drawn liquor and the infused leaves are separately examined. The leaves are judged at once for aroma, before that is lost, and then for appearance and color. Here again uniformity of color is most important. Black teas are best when the color is *bright* and *coppery*, and are less desirable when *green*. Green teas, of course, produce green infused leaves.

The drawn tea is also judged for color and, especially, for clarity; brilliant liquors indicate clean leaves of good strength. Green teas make pale yellowish infusions, whereas black teas make reddish or orange-brown solutions.

The exact color depends upon the purity and, especially, the acidity or alkalinity of the water used, but this factor is constant for a given source of water.

The tasting of the drawn tea liquor is then done, by "slurping" a large spoonful which is held in the mouth for only a few seconds and then expelled. This particular

FIG. 24.—A United States Board of Tea Tasters in action. Left to right: J. Grayson Luttrell, Baltimore; George F. Mitchell, Brooklyn, *Chairman;* Charles F. Hutchinson, New York, Government Chief; Edward Bransten, San Francisco; Walter Hellyer, Chicago; Robert A. Lewis, Boston; and A. P. Irwin, Philadelphia. (*Courtesy of Robert A. Lewis.*)

method of tasting sprays the roof of the mouth with the inspired tea liquid and makes for quick and uniform tasting, with a maximum evolution of aroma within the mouth.

Among the specific standard terms of the taster are *bakey* or *stewey,* which indicates faulty firing, not necessarily at too high a temperature but often to the leaf being held too long or being too thickly spread in the dryer. *Brisk* refers to "live" characteristics. *Colory* refers to the

presence of substances which are colory to the eye but sometimes weak to the palate. *Flavor* is the most valuable character that tea can possess; it can be attained in the highest degree only under favorable climatic and cultural conditions and is greatly influenced by the altitude at which the tea is grown. Often the taster can recognize the tea of a particular estate by flavor alone. *Pungency* refers to astringency without bitterness. *Strength* denotes substance in the liquor and is equivalent to "body," which a chemist-taster finds is closely related to "total extractives." *Thickness* refers to strength and color in combination. *Weathery* is an undesirable character found in teas picked during the mid-season rains, when withering (drying) conditions are unfavorable.

Not all tea tasters in this country follow the English method as detailed above. Some tasters even go so far as to judge teas by appearance and aroma alone and achieve good results without actually mouth-tasting them. Most tea tasters, however, both smell and taste.

The tea taster must be alert to many circumstances and always ready to select the right teas to satisfy most users in each territory. An important requirement is that the tea be suitable for the available water, particularly so that the same color of brew for a given flavor strength will be produced. The paler brewing teas must be used wherever water is even slightly alkaline.

The use of tea bags, first made of muslin and now of paper, is a recent development. Gradually, through the cooperation of tea tasters and producers of the bags, almost perfectly tasteless containers have been secured. Their convenience and cleanliness are doing much to extend the use of tea as a beverage in America.

Coffee Testing

The primary steps in coffee testing are taken in the country where the coffee is grown. First, the coffee is graded into standard classifications, according to the

number of imperfections or the amount of foreign substance present in a given weight of coffee beans. Each classification or grade has definite qualifications with respect to each other grade, and the grades are well standardized between the various countries. The United States government, for instance, has set minimum standards which coffee must meet if imported for consumption. The entire handling of coffee is done on a basis of mutual understanding and responsibility, and there is very little difference between the gradings and testings of the seller in the producing country and the buyer in this country.

The majority of coffees sold in the United States are blends, made up of several coffees, each selected for some outstanding characteristic which reinforces or combines with those of the others to give a predetermined character and closer uniformity. The component parts of a blend may vary somewhat from year to year, because of climatic conditions, variations in rainfall, changes in curing or in handling. This necessitates new selections from various other countries or sections of countries, but whatever blend is established, it is maintained scrupulously by the purchase of each bean type on the basis of carefully maintained standards.

A short discussion of coffee culture will account for some of the differences that may be found in it. Coffee is believed to have been discovered in Arabia about twelve hundred years ago. It still grows wild in tropical Africa, its native home, whence it has been transferred to and cultivated in both the Eastern and Western Hemispheres. Coffee requires a tropical or semitropical country for its growth. The best coffees are grown in the mountainous regions or on the higher plateaus—the higher the altitude, the better the coffee. The various characteristics of coffee are produced by the variety of conditions under which it is grown, such as altitudes, soils, rainfalls, and climates.

Coffee grows on a tree or shrub which, for best results, is kept pruned to a height of from ten to twelve feet. The

blossoms which precede the coffee cherries on the tree are white and grow in clusters along the full length of the branches. These are, in due time, followed by clusters of coffee cherries. The cherry is at first green, but turns red when ripe. Inside the cherry is the coffee bean, usually two oval beans with the flat surfaces together, although sometimes the cherry contains but a single large rounded bean. The coffee bean itself is light-greenish in color. When ripe, the coffee cherry is hand-picked. It is spread out on drying grounds and the outer coverings removed. In some countries, pulp is removed by a washing process, and coffee so treated is known as "washed coffee." After the pulp and foreign matter are removed, the coffee is dried, cleaned, graded, and bagged; it is then ready for transportation to market. The coffee is tested and offered for sale as a type on the basis of an actual sample or a description which gives its grade, size of bean, roasting quality, age, and cup characteristics.

When the coffee arrives, it is sampled by the buyer for an appraisal of the green beans purchased, on the basis of a recognized standard, with attention paid to the grade, size, and color. Next, a test roast is made to see that the coffee is in all respects equal to its description or to its sample. The roast must be made with exactness, for any variance in that operation tends to alter the cupping characteristics of the coffee. Then, it is ground to a given predetermined fineness, and the odor of the dry, ground coffee is noted. Next, the coffee is immediately cupped and compared with a type or standard. In this test, the exact amount of ground coffee must be carefully weighed into each cup. The quantity used varies with the firm, but is usually in the range of 7 to 14 g. (¼ to ½ oz.), which is from a level to a heaping tablespoonful.

In cupping coffees, there are three steps which the blender follows. The coffees are brewed in the cups by pouring on boiling water. These are lined up, before the seated taster, on a revolving table which can easily be

turned for testing samples one against another. The first step used might be called a top- or crust-aroma test, in which the aromas are compared against a standard. In the second step, the grounds of each sample are agitated or stirred with a spoon. In this way the full aroma of the coffee is released for test, and both the strength and character of each sample is shown. Some few minutes

FIG. 25.—Referee board tests coffee. (Routine testing is done by a single operator.) (*Ewing Galloway, New York.*)

later, when the coffees become cool enough to taste, they are sipped to evaluate the taste factors present. When testing Silex or percolator coffees, these are brewed as in the restaurant or the home and poured into cups for testing.

In tasting, the coffee is drawn back into the mouth slowly until the full flavor and character is appraised, after which the liquid is expelled into a specially designed brass cuspidor. The liquid is not swallowed. In cup testing, some of the properties looked for in coffees are richness of body,

"acidity," thickness of brew, flavor, wininess, sirupy character, smoothness, and mellowness. There are certain undesirable properties which must be guarded against, such as sourness, woodiness, "Rioyness," (a crude rawness often found in Rio coffee), mustiness, "hidiness," bitterness, and earthiness. Some of these might be due to conditions of the soil, faulty treatment in curing, or to

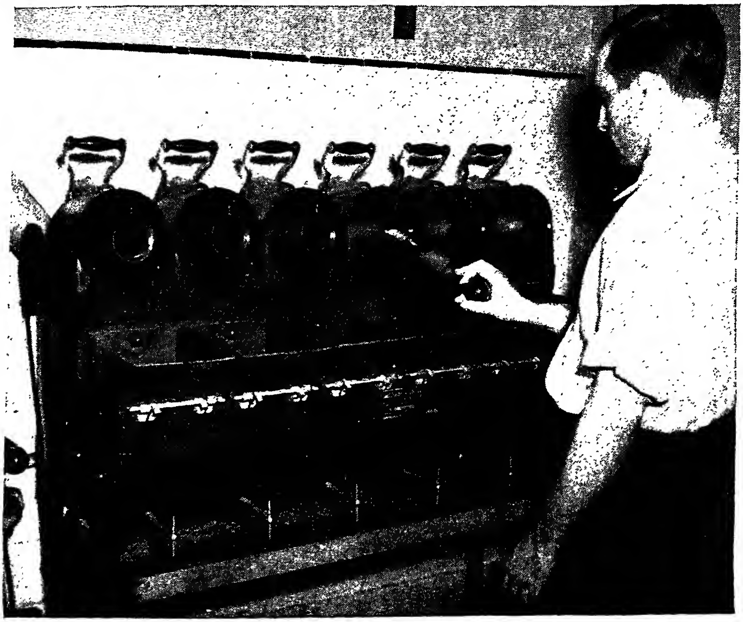


FIG. 26.—Roaster for laboratory-size batches of coffee. (*Black Star Publishing Co.*)

damage that occurred in transit. In testing individual coffees, a single quality at a time is generally looked for, and this is appraised by direct comparison with the standard.

There are indications that certain of the flavor characteristics of coffee may some day be expressed in objective, scientific terms. For example, that totality of taste called "body" appears to bear a direct relationship with what the chemist calls "total extractives." The degree of acidity of the taste of coffee has been found to be amenable to electrical measurement, as pH or by titration. Studies

of the degree of roast plotted against this chemical type of "acidity" have shown that maximum acidity corresponds to very light roasting, and successively lower acidities correspond to "light roast," "medium roast," "high roast," "full roast," and "French roast." While acidity thus decreases with the depth of the roast, there is increase of certain other substances of dextrinelike nature and with burnt taste. The colorimeter is being used for measuring the color depth of the brewed beverage. The optimum degree of roast is one of personal taste, but once established, must be adhered to rigidly.

The coffee tester also must observe carefully the granular condition of the roasted product, in order that the consumer may get maximum results when the coffee is brewed in an open pot, a percolator, by the drip method, or by the vacuum method. There is a best grind of coffee for each method of making the brew. This should contain the correct percentages of powder and of particles of various degrees of fineness to give proper brewing qualities. These percentages are preestablished and carefully watched.

Cereal Beverages

The popularity of liquors depends in no small degree on the skill of the brewmaster in discovering local flavor preferences and in producing for the trade a uniform article that embodies these findings—a practice that other food producers might emulate. Beer and ale are made from a relatively few raw materials: water, malted barley, and hops, with starchy adjuncts such as corn grits or rice, and generally with some form of sugar such as corn sugar, glucose, or cane sugar. Yet a wide variety of flavors is attained by variations of these few materials and the yeast. Strange as it may seem, flavor is also influenced by the equipment and operations used in the plant, known collectively as "plant character."

Beer is produced by the "lager" process, slowly (ten to fourteen days), at relatively low temperatures (45–50° F.),

by a bottom-working yeast. Ale, by contrast, is fermented faster (in six to eight days) at higher temperatures (around 70° F.) by top-working yeasts. Stout and porter are ales, colored deeply by the use of especially roasted and "caramel" malts. In general, ales are lighter in body, somewhat more bitter, and higher in alcohol than beers; but these distinctions are relative and controllable. While bottled beverages are what the labels state, bulk products may be served as "beer" when they are ale, and vice versa, to appeal to the ascertained tastes of particular neighborhoods, regardless of the names by which the beverages are ordered.

Water, as the largest ingredient of beer and ale, is of the greatest importance. In earlier times, the location of a brewery depended upon particular qualities in the water. Other things being equal, the best water still produces the best beer.

Some flavor control is possible by the selection of the malt, and, in general, a blend of malts is used to keep this factor constant. Hops is the flavor that makes beer pleasantly drinkable; it adds to the sweetly insipid flavor of the fermented malted grain a body of taste in which fruitiness and bitterness are prominent and provides a distinctive, fragrant, estery aroma. Fresh hops have strong, vivid flavors, whereas one- and two-year-old hops have more mellow character. "Old olds," however, may be somewhat cheesy and are to be avoided. It is common practice to use blends of medium-old and fresh hops, to secure a balance of the good qualities of each and to suppress the less desirable—especially any "greenness" or herbiness of too-fresh hops.

The kind of yeast used is of the greatest importance in brewing, and it must be maintained true to character. The bacteriologist is an important man in a modern brewery. His task is to control the yeast and to avoid bacterial contaminations, which can raise havoc with flavor, especially with the slow-fermenting beer. Because of the high food value and liquid condition of ales and

beer, brewing must be carried out with strict attention to asepsis. Cleanliness is practically the measure of success, and nearly half of the labor in a good brewery is used for keeping the plant and equipment clean.

During the first stages of fermentation, "blackheads" rise to the top of the fermentation vessels. These coagulated masses contain some of the resinous portion of the hops and are rich in bitter ingredients. Where delicate flavors are desired, the blackheads are carefully skimmed off and discarded. After the skimming, the fermentors are closed and carbon dioxide is allowed to accumulate. This gas is richly perfumed with the more volatile ingredients of the hops, and it must later be pumped back into the beer at the time of bottling or barreling, not only to make the beer lively but to maintain the bouquet.

The flavor of the finished liquor must have the "3 *B*'s"—body, bitterness, and bouquet—the first and last of which may be stressed in advertising. Actually, bitterness is a vital part of the flavor of beer and ale. It should be a pleasant fugitive bitterness, however, that quickly disappears from the mouth the moment the liquid is swallowed. The bouquet is sometimes sufficiently distinctive, so that by it alone particular brands may be distinguished. Bottled beers tend to have a slightly cooked flavor due to the pasteurization. This is absent from the draft liquor. Careful control of conditions, as in the case of milk, keeps this cooked flavor at a minimum, so that most people are not even aware of its existence.

The Tasting of Wine

Because the wines being tasted today are more or less strange and because the yardsticks for judging wines developed by each of us may not be easily applied to them, it is felt that a review of the characteristics by which a wine is judged is in order.

Color.—A good wine should be clear, even brilliant, in color, whatever its tint may be.

Bouquet.—Two factors really compose bouquet—volatility and perfume. Great red wines, such as the best Burgundies, have both to a marked degree. Some wines, among which are several produced from native American grapes, may have pronounced perfume without being very volatile.

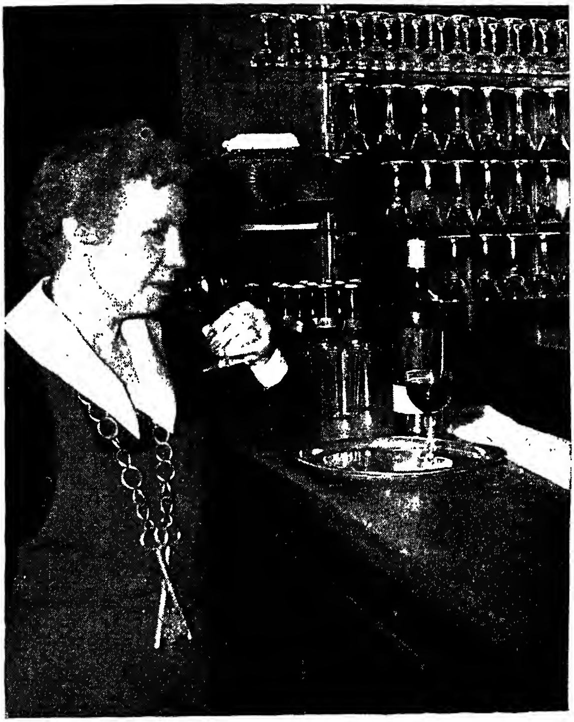
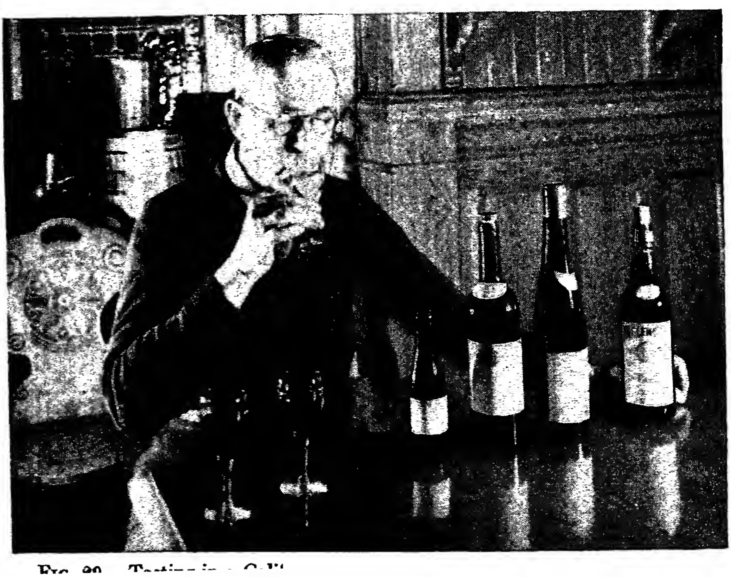


FIG. 27.—Mrs. Elizabeth Bird, known as "Francine," is probably New York's only woman wine steward. As *sommelière* of the Hotel Algonquin, she is mistress of the wine cellar and adviser to gourmets. (*Wide World Photos, Inc.*)

Richness and fullness of bouquet come only with years of careful breeding.

Flavor.—Not only must the flavor be clean and not acid or musty, alive and not flat, deep and not just superficial, but in a good wine it must be suave and supple as the vibrations of a violin string rather than jagged and rough as the sound of a crosscut saw.

Fig. 28.—A South African wine taster, A. Dewet Theron, examines wines for clarity and color. (*Press Association, Inc.*)



Body.—A good wine may be light or heavy of body, but in all cases it must be of "fine grain" or "closely knit together." A flabby wine is not a good wine.

Finally, a good wine should be well balanced in each of its characteristics, and these in turn should be balanced together. A heavy-bodied wine, for example, with no bouquet and little flavor is not well balanced.

Chapter 15

Commercial Quality Scoring

Foreword

MOST of the perishable food produced in this country by large organizations is scored in some way to control its quality. Scoring has perhaps its greatest use in the dairy industry. It keeps producers aware that sanitation, flavor, and other evidences of consideration for the consumer are of current commercial importance. It goes a long way toward securing a high average of quality in the goods and their acceptance by the public.

Although under present methods of scoring dairy products, much butter, for example, is passed that later may be found not to age well, and some is undoubtedly graded down that is fundamentally sound, these methods are serving to maintain quality at a high average level. As time goes on, instrument testing will probably supersede the less accurate organoleptic tests now used.

The flavor of the highest scored butter is not preferred by everyone; some people really like a cowy taste, or excess of salt, or even a bit of rancidity. With present scoring practices, these demands may be met by separating butter into lots having the particular characteristics desired. Customers of more refined tastes are provided with butter with a higher rating. No doubt with time the tastes of most people will be raised by their continually getting butter somewhat better than that to which they were formerly adjusted.

Examples cited in this chapter are the scoring of dairy products, including milk, butter, cheese, and ice cream; the scoring of dried eggs for palatability; judging the quality of meat; and the scoring of bread and cake.

Defects of Milk and Dairy Products[1]

In scoring, judging, or tasting dairy products, it is necessary for the person doing the tasting to have in mind a very definite ideal for flavor, body, sediment, appearance,

FIG. 30.—Washington Platt uses scoreboard he devised for evaluation of milk products. (*Courtesy of Borden Company.*)

and color of each product examined. That ideal can only be obtained after much comparative tasting of a number of different samples. Each flavor tasted must leave in the mouth a good, wholesome aftertaste of the dairy product examined. The color of the product must have a definite eye appeal; the body must be neither too heavy nor too thin, depending upon the product examined. In other words, the product must definitely appeal to the

[1] Written in cooperation with W. D. Barrett, Director of Laboratories, Whiting Milk Co., Boston, Mass.

eye, the nose, and the palate. As stated above, this ideal must be fixed in the mind of the taster, and it can be so fixed only by continued tasting of samples in comparison with each other.

A few simple rules should be followed in tasting.

FIG. 31.—Butter inspector appraises the appearance and aroma of a "plug" sample of butter. A tasting will complete his examination. (*Courtesy of Beatrice Creamery Company.*)

1. Have liquid products at a temperature of about 90°F.

2. Concentrate on tasting. Do not think and talk of other things. Since flavors are often delicate and the senses are also delicate, this careful concentration is essential.

3. Do not swallow the product. Roll it around slowly in the mouth until the flavor is entirely absorbed by the taste sense (concentrating all the time). Then spit it out. If this procedure is followed, a first taste will be imparted

when the product is first put in the mouth; a second taste while it is being rolled in the mouth; and an aftertaste after it is spit out. These successive tastes must be compared with the ideal you have in mind for the particular product being tasted.

4. Be sure the mouth is rinsed out well with lukewarm water before proceeding to the next sample.

5. Do not taste too rapidly. If the mouth becomes chilled or too busy in tasting, the sense of taste is lost.

6. Do not taste for flavor, body, and texture at the same time. Taste first for flavor and then a second time for body and texture.

Flavor Defects and Their Causes for Three Important Dairy Products

1. *Milk*

FLAVOR DEFECT	CAUSES
Barny, cowy	Absorbed from the surroundings in the process of production
Feed, ensilage	Feeding immediately prior to milking; also certain weeds and feeds that the cows may eat in pasturage (garlic, onions, turnips, etc.)
Metallic Cardboard Oxidized Tallowy Oily Burnt feathers	Four principal causes: 1. Natural conditions affecting the cows (often whole herds) 2. Copper and iron catalysts, dissolved from pasteurization equipment 3. Action of sunlight (important principally for homogenized milk) 4. Irradiation by ultraviolet light (often cause of burnt-feather defect)
High acidity Sour	Improper handling—inadequate refrigeration and age
Salty	Diseased udder (mastitis, etc.)
Bitter	Bitter-flavored weeds in feed; and lipase
Disinfectant	Sometimes the early stages of oxidized flavor
Neutralizer	Excessive addition of neutralizer
Rancid	Enzyme action and bacterial toxins

2. *Butter*

The flavors to be looked for in tasting butter can best be discerned when the butter is placed in a clean glass bottle and warmed to a soft but not molten condition. When butter is warm, its defects can more easily be detected.

FLAVOR DEFECT	CAUSES
Salty	Excessive salt used
Rancid	Old, oxidized products used in the butter or improper storage temperatures; also bacterial action
Metallic	Frequently is incipient rancidity; occasionally due to dissolved metals
Fishy	Enzymatic action setting free amines
Feed	This can be caused by garlic, onion, and other objectionable feed flavors
Unclean or musty	Many possible causes; sometimes due to yeasts and molds
High acid	Excessive acidity due to high acid cream used improperly in its manufacture
Neutralizer	Excessive neutralizer in cutting the acidity of the cream
Putrefaction and cheesy	Protein decomposition

In sampling butter, it is important to smell the butter, for often the odor given off is characteristic of the flavor to be found in the butter. In other words, a clean odor will usually mean a clean butter.

3. *Cheese* (Cheddar type)

FLAVOR	CAUSES
Musty	Old culture, or contamination by wild yeasts and molds
Old	Indication of runaway or other faulty curing
Metallic	Metals dissolving from equipment used in manufacturing
Salty	Too much salt; or abnormal milk
Flat	Not enough acidity or salt; improper manufacture or curing; or defective culture
Bitter	Uncontrolled enzymatic action, due to improper processing or curing

BODY DEFECT	CAUSES
Hard Crumbly Grainy Soapy	1. Improper processing and curing control 2. Ununiform milling of the curd 3. Improper pressing and draining with respect to pressure and time 4. Improper waxing and turning of cheeses 5. Improper humidity of the curing room 6. Improper temperature of curing room

A Chart to Aid in Scoring Milk Flavor[1]

"In the chart here are included the five classes into which milk is divided on a basis of flavor as suggested by Babcock and Leete. The perfect score for flavor is 25. Milk that scores 23 or above is designated as *excellent,* 21 or 22 *good,* 18, 19 or 20 *fair,* 12 to 17 inclusive *poor,* and 11 or below is *bad.* A fractional score in no case serves to raise a sample into a higher class than it would enter without the fraction. For instance, a sample scoring 20½ is classed as fair, not as good. Eighteen different defects in flavor are enumerated. It is recognized that some of these terms are subject to challenge. Again some judges would choose to add other terms. In a year's work with this chart, during which time about 1,000 milk samples have been scored by five or six judges, a few suspected off-flavors other than the eighteen enumerated have been encountered. However, none of these other flavors has been observed with enough certainty or frequency to justify its inclusion in the chart.

"In formulating this chart it was believed each flavor could be resolved into at least three degrees of intensity. Accordingly, the terms 'slightly' and 'very' are employed to reveal the lower and upper gradations in the flavor. These terms, or comparable ones, are used by all judges. The effort in the chart is to ascribe some numerical significance to the different gradations.

"It is observed in several cases here that two gradations of a given flavor are suggested under the same class. For instance, milk that is either 'acid' or 'very acid' is classed as *bad.* Again, milk that is 'slightly bitter' is held down into the same class as 'bitter' milk. In devising the chart decisions that relegated the different flavor gradations into the various classes were based on experience and usual practice in scoring milk. They are entirely arbitrary, and no effort is made here to defend them. On the whole,

[1] E. I. Fouts and Earl Weaver, *Journal of Dairy Science,* **18,** 51, 1935.

however, it is believed few workers would have occasion to deviate greatly from the suggestions as given.

"Frequently, in using this chart the judges have found occasions which prompted them to use an additional gradation to reveal a 'very slight' intensity in some flavor.

Flavor Defects and Suggested Scores[1]

(S. indicates *slightly*; v. indicates *very*)

Class	Excellent	Good	Fair	Poor	Bad
Scores	23 and above	21 and 22	18 to 20	12 to 17	11 and below
Acid	......	....	....	S. acid	Acid, v. acid
Bitter	......	....	....	S. bitter and bitter	V. bitter
Cooked	......	S. cooked	Cooked	V. cooked	
Cowy	......	S. cowy	Cowy	V. cowy	
Disinfectant	......	....	....	S. disinfectant	Disinfectant & v. disinfectant
Feed	......	S. feed	Feed	V. feed	
Flat	......	S. flat	Flat	V. flat	
Metallic	......	....	S. metallic	Metallic & v. metallic	
Musty	......	....	....	S. musty	Musty & v. musty
Nutty	......	....	S. nutty	V. nutty and nutty	
Oxidized	......	....	S. oxidized	Oxidized & v. oxidized	
Rancid	......	....	....	S. rancid	Rancid & v. rancid
Salty	......	....	S. salty	Salty	V. salty
Sharp	......	S. sharp	Sharp	V. sharp	
Stale	......	....	S. stale	Stale & v. stale	
Sweet	......	S. sweet & sweet	V. sweet		
Watered	......	....	S. watered	Watered & v. watered	
Weedy	......	....	....	S. weedy	Weedy & v. weedy

[1] Chart prepared by E. I. Fouts and Earl Weaver.

Such occasions have arisen most frequently with the salty samples. It is suggested in the chart that milk found to be 'slightly' salt should be classed as *fair*. However, the judges sometimes detected a very slight taste of salt that was in no wise objectionable. They felt it was unduly critical to hold the milk down to *fair* so used the gradation 'very slightly' salt and kept the milk in the *good* class."

Typical Ice-cream Score Card[1]

Flavor

Score 45–40			No criticism
Score 39.5–37.5	Cooked	Lacks flavoring	Too high flavor
	Egg	Lacks freshness	Too sweet
	Lacks fine flavor	Lacks sweetness	
Score 37–34.5	Cooked	Metallic	Salty
	Feed	Old ingredient	Storage
	High acid	Oxidized	Unnatural flavoring
Score 34–31	Feed	Old ingredient	Salty
	High acid	Oxidized	Storage
	Neutralizer	Rancid	Unclean

Body and texture

Score 30–29.5			No criticism
Score 29–27	Coarse or icy	Fluffy	Weak
	Crumbly	Soggy	
Score 26.5–25	Buttery	Fluffy	Weak
	Coarse or icy	Sandy	

Melting quality

Score 5			No criticism
Score 4.5–3	Curdy	Does not melt	

Color and package

Score 5			No criticism
Score 4.5–3	Color unnatural	No parchment	Unclean can
	Color uneven	Rusty can	

The complete score card also includes an item "Bacteria (15)," to be determined by bacteriologist.

Scorer will score each item and write criticisms in space provided. Smallest cut on any item ½ point.

A combination of two or more defects within a section often justifies giving a lower score than that indicated for either defect alone.

Normal range of score on flavor	31–40
Normal range of score on body and texture	25–29.5
Normal range of score on melting quality	4–5
Normal range of score on color and package	3–5

[1] Courtesy of Swift & Company, Chicago.

Score Card for Cheddar Cheese[1]

(Front of card)

Place____

Class____________________Exhibit No.____________________

	Perfect score	Score allowed	Remarks[2]
Flavor	45		
Body and texture	30		
Finish	15		
Color	10		
Total	100		

Exhibitor____

Address____

(Signed)____

Judges

Date____________________

Cheese scoring 93 or higher	U. S. Fancy
Cheese scoring 91 to 92.5	U. S. No. 1
Cheese scoring 88.5 to 90.5	U. S. No. 2
Cheese scoring 86 to 88	U. S. No. 3
Cheese scoring less than 86	U. S. Undergrade

[1] Courtesy of Swift & Company, Chicago.

[2] See directions for scoring on other side.

Score Card for Cheddar Cheese

(Back of card)

The following may be used as a guide for scoring Cheddar cheese:

Flavor

Score 45–50 . . . . No criticism
Score 39.5–39 . . . . Flat
Score 38.5–37.5 . . . . . Slight acid, slight bitter, slight feed, slight unclean, slight weedy, slight cowy
Score 37–36 . . . . Acid, unclean, heated, slight fruity, cowy, bitter, slight moldy, slight fermented, slight rancid
Score 35.5–35 . . . . Fermented, fruity, rancid, yeasty, moldy
Score below 35 . . . . . When body, texture, color, and finish are nearly perfect, and any flavor is so offensive that it is necessary to give a total score of less than 86

Body and Texture

Score 30–29.5 . . . . No criticism
Score 29–28 . . . . Slight open, slight weak, one or two sweat holes, flaky
Score 27.5–26.5 . . . . . Open, slight corky, slight pasty, weak, slight mealy, slight gassy, curdy[1]
Score 26–25 . . . . When flavor, color, and finish are nearly perfect, and body and texture defects are so pronounced that it is necessary to give a total score not higher than 87

Finish

Score 15 . . . . No criticism
Score 14.5 . . . . Light spots, slight wrinkled bandage, slight uneven surface, slight soiled, slight moldy, slight huffed, slight scaly paraffin
Score 14 . . . . Cracked rind, huffed, rot spots, moldy, soiled, uneven surface, scaly paraffin, wrinkled bandage
Score below 14 . . . . . When flavor, body, texture, and color are nearly perfect, and finish defects are so serious that it is necessary to give a total score of less than 86

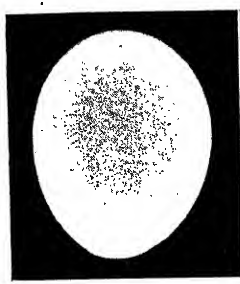
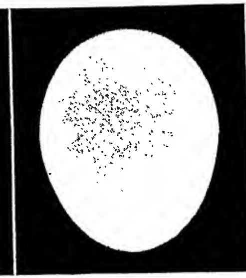
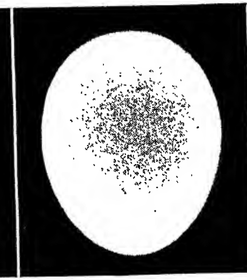
Color

Score 10 . . . . No criticism
Score 9.5 . . . . Seamy, acid cut
Score 9 . . . . Wavy, mottled
Score below 9 . . . . . . When flavor, body, texture, and finish are nearly perfect, and color defects are so pronounced that it is necessary to give a total score of less than 86

NOTE: The flavor criticism "green" has been left out. Green does not mean anything. A cheese can be young or green and have no flavor or flat flavor, or it can have any off-flavor.

[1] Curdy is a defect on cured cheese, but it is not on young cheese.

Eggs. Retail Grades and Uses[1]

GRADES (interior quality only)	AA	A	B	C
Uses	Excellent table eggs	Fine table eggs	Table, cooking and baking eggs	Cooking and baking eggs
Candling Appearance (white shells)				
Shell	Clean and sound	Clean and sound	Clean, sound, may be slightly abnormal	Clean, sound, may be abnormal
Yolk	Outline slightly defined	Outline fairly well defined	Outline well defined, slight defects permitted	Plainly visible (appears dark) some defects permitted
White	Clear and firm	Clear and reasonably firm	Clear but slightly weak	Weak and watery, small meat spots permitted
Air cell	⅛ in. deep, regular or slightly wavy	¼ in. deep, regular or slightly wavy	⅜ in. deep, movement up to ⅜ in.	⅜ in. deep, may be bubbly or free

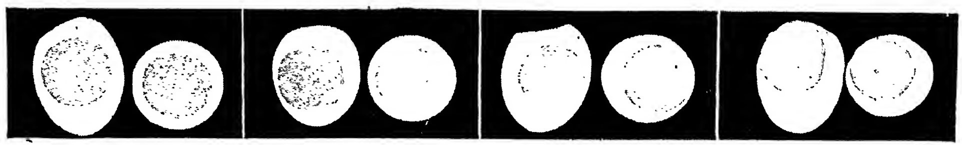
Broken out

Top view

Side view

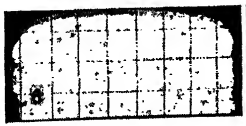
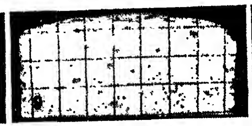
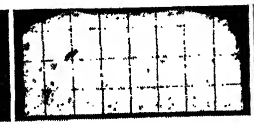
Area covered	Small	Moderate	Wide	Very wide
Yolk	Round and upstanding	Round and upstanding	Somewhat flattened	Very flattened, breaks easily
Thick white	Large amount, standing up well	Large amount, standing up well	Medium amount, flattened	Small amount
Thin white	Small amount	Small amount	Medium amount	Large amount

Hard cooked



Yolk	Well centered	Just off center	Off center	Not centered; outline irregular

[1] Photos and material prepared by New York State College of Agriculture and Colorado State College; plates courtesy of U. S. Egg & Poultry Magazine and Beacon Milling Company, Inc., Cayuga, N. Y.

Fried				
White	Upstanding	Somewhat spread out	Spread widely, mostly thin	Spread out over large area
Yolk	Round, upstanding	Round, upstanding	Somewhat flattened	Very flat
Angel-food cake (similar results with other types of cakes)				
Texture and volume	Excellent texture and volume	Excellent texture and volume	Excellent texture and volume	Good texture and volume but cake definitely shrunken in depth and width
Albumen whipping time (egg white)	$2\frac{1}{2}$ min.	$2\frac{1}{4}$ min.	2 min.	$1\frac{3}{4}$ min.
SIZE	Weight requirements per dozen for above grades are as follows: jumbo (28 oz.), extra large (26 oz.), large (24 oz.), medium (21 oz.), and small (18 oz.)			

Palatability Scoring of Dried Eggs[1]

F-8a Palatability panel.—The panel shall consist of not less than three individuals, selected for their ability to distinguish known quality samples of egg and duplicate their results within one-half point.

F-8b Scoring system.

Score	Description
10	Flavor of a first-quality fresh egg when prepared as a straight egg dish, e.g., scrambled egg
8	Flavor of a good-quality egg having no detectable off-flavor
7	Slight but not unpleasant off-flavor
6	Definite but not unpleasant off-flavor, lowest level acceptable as an egg dish
4	Off-flavor—strong and unpleasant as an egg dish, lowest level acceptable for baking purposes
2–0	Extremely unpleasant to repulsive

F-8c Procedure.—Twenty-four g. of sample are mixed with 100 ml. of water and thoroughly reconstituted in a mechanical mixer. The sample is transferred to a 400-milliliter beaker and cooked in a water bath at 90 to 95°C., with constant stirring (using glass rods) until the mixture reaches the consistency of scrambled egg. Hot 10-gram portions are placed in coded Petri dishes and covered. The samples are then immediately served to the judges.

F-8d Palatability Score.—The palatability score shall be determined by averaging the scores of all judges. However, no judge's score shall be used for this purpose if the duplicate determination does not agree to within one-half point.

F-8e Notes.

1. The cooked samples shall be scored in duplicate in a quiet, odor-free room, within the two-hour period prior to a meal
2. Not more than twelve determinations shall be made by any judge at any scoring session
3. Judges shall not converse or in any way influence each other's decision
4. Smoking, and cosmetics on the person, shall not be permitted during the scoring period
5. Individuals cooking, preparing, and serving the samples shall not be judges

[1] This scoring method was taken from Tentative Specification of U.S. Quartermaster Corps, No. 117A, dated January 28, 1944. Other parts of this specification include certain general requirements and a fluorescence test.

How Quality in Meat Is Judged[1]

"For convenience in buying and selling, many commodities are classified and graded, that is, divided into lots or groups which have more or less uniform characteristics. Meat, which usually is produced and processed far from the market in which it is sold, is such a commodity. In

[1] Excerpts are from *Meat Buying Manual,* published by The National Live Stock and Meat Board, Chicago.

formulating a system of classifying and grading, it is necessary to set up certain specific standards which are described in terms which are definitely understood by seller and buyer. Terms which are used to designate the more important characteristics of beef, pork, veal and lamb are: Conformation, finish, and quality. Since these characteristics are factors involved in judging all kinds of meat, they are defined here. The consumer will find it helpful to understand these factors which are the basis of judging and grading meat.

Conformation

"The term conformation covers the general build, form, shape, contour of outline of the carcass, side, or cut. Good conformation implies short necks and shanks, deep plump rounds, thick backs and full loins, well-fleshed ribs and thickness of flank. In other words, the most desirable cuts from loins, ribs, and round have full muscles and a large proportion of edible meat to bone.

Finish

"The term finish refers specifically to the quality, amount, color, and distribution of fat. The best finish implies abundant marbling (intermingling of fat with lean) and a smooth even covering of firm fat over the exterior surface of the carcass, side, or cut.

"A high degree of finish adds to the attractiveness of the cut, but its greatest significance is due to the fact that palatability, which includes juiciness, depends upon a certain proportion of fat being present.

Quality

"The term quality as it applies to meat is limited to the factors which affect the palatability of the cooked meat, provided the cooking has been done properly. Quality, therefore, refers to certain characteristics of the flesh and

fat included therein. Quality pertains primarily to the firmness and strength of both muscle fiber and connective tissue, for these affect the tenderness of the meat. Palatability also involves the amount, consistency, and character of the juices which surround and permeate the muscle fiber and connective tissue. Although cooked meat should yield a high proportion of juice, the uncooked meat should be of such a consistency that the flesh when chilled remains firm and resilient.

"The factors of conformation, finish, and quality are the measuring sticks applied in judging all meats, but they will differ in beef, pork, lamb, and veal. In other words, the character and color of the fat and lean will not be the same in beef as it is in pork; beef will have a heavier fat covering than veal; the color of one kind of meat differs from the color of another, etc. These individual differences will be explained in the sections devoted to the four kinds of meat."

Selection Of Beef

"*Characteristics of Beef.*—Beef of good quality has a smooth covering of firm, creamy white fat over most of the exterior. The lean is red, well marbled with creamy white fat.

"The texture of the lean is firm and velvety in appearance and is fine in grain. The bones in young beef are porous and red in contrast to white, flinty bones in older animals.

"*Identification of Beef Cuts.*—Many cuts of meat are overlooked by the shopper for meat because she does not recognize them in the market, nor know how to prepare them. It is very helpful in purchasing meat to be able to identify all of the different cuts and to know how to prepare them in order to bring out their best qualities.

"The cuts may be recognized by their shape, the structure of the muscles, and by the bones which they contain. A knowledge of the section from which the cut comes is useful because cuts of beef vary in tenderness, and the

method of preparation differs according to the degree of tenderness.

"In general, the tender cuts are from the supporting muscles which lie along the backbone. The less tender cuts are the muscles of locomotion which are found in the

Beef Cuts and Their Uses

Wholesale cut	Description	Retail cuts	Beef specialties
Round	Well-flavored, with rump and hand shank off, has very little bone	Steaks, pot roasts	Brains— Cream, scramble with eggs, cutlets
Rump	Well-flavored, contains aitchbone, knuckle joint and tail bone; to facilitate carving some or all of bones are removed	Corned beef, pot roasts, steaks	Heart— Braise, cook in water Liver— Fry, roast whole or as loaf, braise
Loin end	Tender, juicy, varying amounts of bone	Sirloin steaks	Tongue (fresh, pickled or corned)— Cook in water
Short loin	Tender, juicy, contains portion of tenderloin	Porterhouse, T-bone, club steaks	Tripe— Cook in water, cream
Flank	Thin, practically boneless, coarse-grained, well-flavored	Flank steak, stew meat	Oxtail— Soup, braise
Rib	Tender, juicy, contains rib bones and "eye" muscle	Roasts, rib steaks	
Chuck	Juicy, well-flavored; muscles run in different directions	Pot roasts, steaks, stew meat	
Brisket	Layer of fat and lean; contains rib ends and breastbone	Fresh brisket, corned brisket	
Plate	Rib ends, layers of fat and lean	Short ribs, "boiling" beef, boneless roll	
Shanks	Considerable bone, connective tissue, varying amounts of lean	Soup bones, cross-cut shanks	

leg and shoulder. In the latter sections there is more connective tissue and the muscle fibers have developed thickened walls.

"The food value of the different kinds and cuts of meat is essentially the same regardless of whether they are tender or less tender; therefore, the tender cuts have no advantage over the less tender cuts on the score. The only practical difference in food value between cuts is due to the fat content; fat cuts yield more calories than lean cuts, but lean cuts have a higher percentage of protein."

Selection of Pork

"*Characteristics of Pork.*—The color of the lean of young pork is a grayish pink, turning to delicate rose color in the older animal. Color of meat is not actually a factor of quality, but merely an indication of the quality of a given piece of meat. In pork, because of uniformity in marketing age, there are only moderate differences of color. The flesh is relatively firm and fine grained and free from excessive moisture. The lean is well marbled and covered with a firm white fat free from fibers. The fat not only indicates quality, but adds palatability. Classifying pork carcasses differs to some extent from classifying other kinds of meat. One type of carcass is best suited for sale as fresh cuts, while other types of carcasses are best suited for cured products. The weight of the carcass very frequently determines the use to which it is put at the packing plant.

"*Identification of Pork Cuts.*—Since pork is sold both fresh and cured, the cutting is done in the packing plant instead of in the retail market. About three-fourths of the pork products are sold as fresh and cured meats and the remainder as lard and sausage.

"Some cuts are in demand for consumption as fresh pork, while others are in greatest demand as cured pork. Many pork cuts are sold both fresh and cured. Consumer demand influences the method of cutting and determines what particular kind of cut will be made.

"A study of the various cuts as they are sold in the retail market will enable the buyer of pork to recognize them."

Pork Cuts and How to Use Them

Wholesale cut	Description of cut	Retail cuts	Pork specialties
Feet	Bone, skin, not much meat, but delicate	Pigs' feet	Brains—Fry, scramble with eggs
Ham or leg of pork	Solid meat, very little bone; fresh or smoked	Roasts, steaks	Lungs—Braise Head—Headcheese
Bacon	Cured and smoked, fat streaked with lean	Breakfast bacon	Heart—Braise
Loin	Tender, lean meat; may be boned and cured, as Canadian style bacon	Roasts, chops, tenderloin	Liver—Fry, broil, braise, roast whole or as loaf
Picnic shoulder	Well-flavored, largely lean meat, fresh or smoked	Roasts, steaks	Tongue—Cook in water Tails—Cook in water with vegetables
Boston butt	Higher in lean than any pork cut, very little bone	Boston butt, steaks, smoked shoulder butt	Ears and snouts—Cook in water with vegetables
Spareribs	Lean and fat, good flavor	Spareribs	

Selection of Lamb

"*Characteristics of Lamb.*—The flesh of lamb is pinkish red in color. The color of the lean in yearling lamb and mutton is a deeper red. The lean is fine grained and has a velvety texture. The fat is clear, white, and brittle. The lean is marbled with fat. The bones are porous and reddish in color. In young lamb the fore feet may be broken off exposing four well-defined ridges. This is known as the break joint. In older lamb or yearlings the break joint is hard and white instead of porous, moist, and

reddish. This joint cannot be broken by the time the mutton stage is reached.

"The break joint is a sure and simple means of identifying lamb; however, according to government figures about 90 per cent of the sheep are marketed as lambs. This is due to the fact that lamb is preferred to mutton in America. High quality lamb is available at all times in most markets.

"*Identification of Cuts.*—As in beef, one may learn to identify the cuts by studying the shape, muscle, and bone structure. Legs, loin chops, and rib chops are the lamb cuts most in demand. The less used cuts are the shoulder and breast sections. Roasts and chops from these are equal in tenderness and flavor to the leg, loin, or rib; therefore the preparation of these cuts presents no special problem.

Lamb Cuts and How to Use Them

Cut	Description	Retail cuts	Lamb specialties
Leg	Solid meat, fine quality	Roasts, steaks	Brains— Cream, braise, scramble with eggs
Loin	Tender, high quality, small amount of bone	Chops, English chops, roast	Heart— Braise, cook in water
Rack	Tender, high quality; contains rib bones	Chops, roasts, crown roast	Kidney— Fry, broil, cook in water
Shoulder	Tender, well-flavored; often boned and rolled or made into cushion-style roast	Roasts, chops, stews, loaf	Liver— Fry, broil, braise Tongue— Cook in water
Breast (including flank)	Meat tender, but not so fine in grain as other sections	Stews; boned and rolled for roast; pocket for stuffing	

"Over half of lamb carcasses are divided into wholesale cuts before they are received at the retail market. The major cuts which are recognized in most markets are the fore and hind saddles. The hind saddle consists of the legs,

flanks, and one pair of ribs. The fore saddle consists of the hotel rack, the chuck or shoulder, the breasts, and shanks."

Selection of Veal

"*Characteristics of Veal.*—The lean of veal is a grayish pink, almost white in color. The meat is very fine in grain, fairly firm and velvety in texture. It is not marbled with fat. There is little fat and this is clear, firm, and white. The bones are porous, soft, and red, and the ends of some of them are still pliable. Veal has a fine delicate flavor, which combines well with other foods.

"To be able to recognize quality in meat in the piece one must have a knowledge of color, texture, form, and finish of the meat.

Veal Cuts and How to Use Them

Cut	Description of cut	Retail cuts	Veal specialties
Leg........	Solid meat, small percentage of bone, little waste	Roasts, cutlets, veal birds	Brains— Cream, scramble, fry
Rump.....	Excellent quality; corresponds to rump of beef	Roast	Heart— Braise, cook in water
Loin.......	Excellent quality, more bone than leg	Chops, roasts, kidney chops	Kidney— Broil, meat pie, fry, cook in water
Rib........	Excellent quality	Chops, Frenched chops, roasts	Liver— Fry, broil, braise, roast whole or as loaf
Breast.....	Narrow, thin strip of meat with breastbone and lower portion of ribs	Stuffed roast, stews, jellied veal	Tongue (corned, smoked, fresh)— Cook in water Sweetbreads—
Shoulder...	Tender, juicy, and well-flavored	Roast, boned and rolled roast, chops, pot roasts	Cream, braise, broil, fry
Shank.....	Little meat, fine flavor	Pressed veal, stock, stews	
Flank......	Good flavor, no waste	Stews, pressed veal	

"*Identification of Cuts.*—Wholesale veal cuts are very much like those of beef, except they are smaller and the retail cuts made from them are smaller. In general, veal cuts are from one-third to one-half the size of the same cut of beef. The cuts from the loin of veal are called loin and kidney chops instead of steaks, as they are in beef. The loin is sold also as a roast. The cuts from the rib section are known as rib chops. Strictly speaking, veal cutlets are slices cut from the leg and correspond to round steaks in beef. Both loin and rib chops are sometimes sold as cutlets.

"The individual cuts, such as steaks and chops, are economical to use for a small family. For the larger family roasts from the leg and the shoulder are economical. It is a common practice to bone out the shoulder and roll it. Roasts of any desired size may be cut from this roll.

"Heart, tongue, and liver of veal are considered highly desirable. These have little or no waste. Sweetbreads, which are the thymus gland, are another veal specialty which is a great delicacy."

The Scoring of Bread and Cakes[1]

Bread

The flavor of bread, at its best, combines wheaty substance with fermentation "sauce." It may also have the richness that comes from high milk solids, sugar, malt, and shortening, or the leanness characteristic of Italian, Belgian, or French breads, which are made with only flour, water, salt, and yeast. Regardless of the type, the clean taste of wheat must be prominent, and only the pleasing fermentation products evident.

For an unbiased judgment, samples of bread should be picked up at random on the market and brought back into the plant for observation, rather than be taken directly from a run.

[1] Written in cooperation with A. A. Schaal and H. P. Montminty, Consumer Service Department, Lever Brothers Company, Cambridge, Mass.

Conclusions should never be drawn concerning a loaf of bread without eating it. Periodically, bread should be tasted in bread-and-butter form, toast-and-butter form, sandwich form, and toasted-sandwich form. After all, these are the ways in which the bread will be consumed by the public, and not as plain dry bread.

The scoring system given here has chiefly the consumer's interest in mind; it is simple and practical.

Scoring of Bread

	Points
1. *Appearance of outside of loaf*	
Volume—the bread should be well-risen, with good size for the amount of dough used	10
Character of crust—crust should generally be tender and thin (thick on "hard" breads)	5
Color of crust—a uniform brown	5
Symmetry of form—pan loaves must have square ends and have an even break or shred on the side	5
2. *Interior characteristics*	
Color of crumb—should either be white or a light creamy color (depending on the formula used and whether or not bleached or unbleached flour was used)	10
Grain—even cell structure throughout without large holes	10
Texture—tender and moist	15
3. *Flavor and eating quality*	
Flavor—pleasing flavor of wheaty and fermented character. (The loaf may be squeezed to pump out enclosed odoriferous air)	20
Chewability—The crumb should be tender, and there must be no interference from toughness or any balling up effect in the mouth, on chewing.	20
Total	100

Cakes

There are many ways to score cakes. One may find in the literature long detailed lists with numerous characteristics against which adjective ratings are given. Such a complex scoring may seem attractive at the start, but almost invariably operators will find its use so laborious

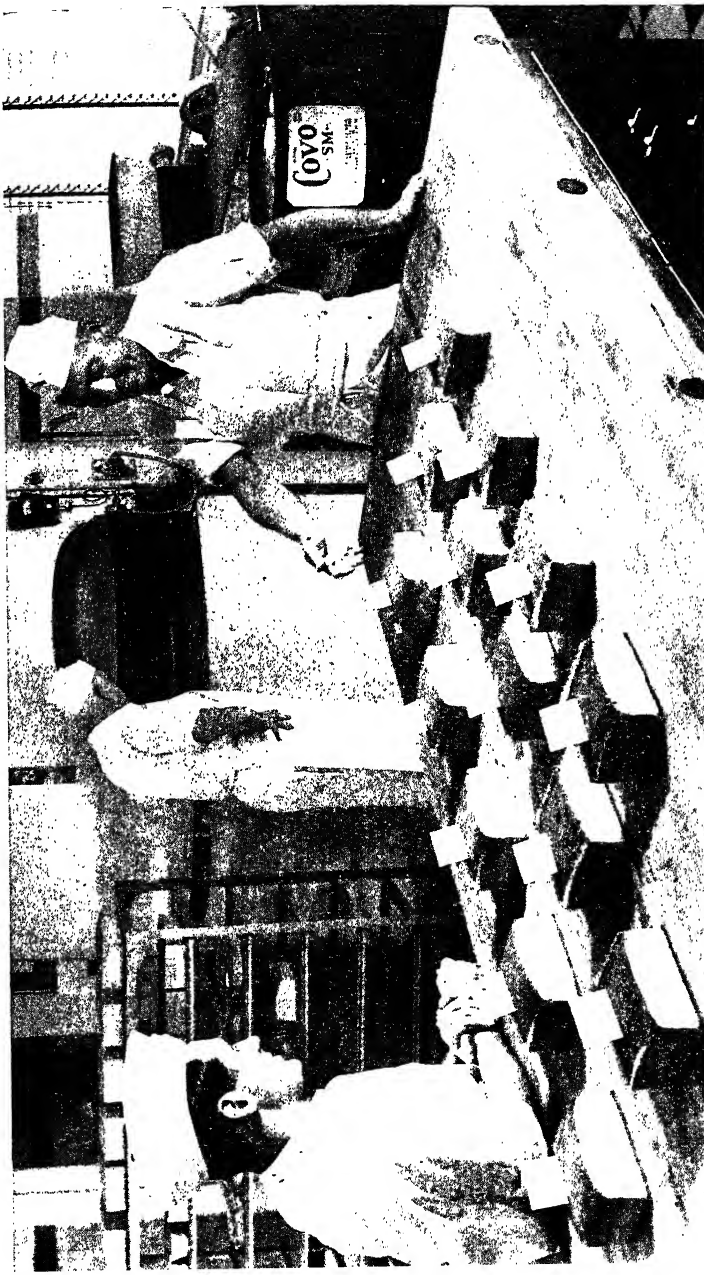


FIG. 32.—Judging uniced cakes for appearance, grain, texture, and flavor. (*Courtesy of Lever Brothers Company.*)

that they will abandon it and produce simpler systems of their own. What is wanted is a scoring system sufficiently detailed to show what is good and what is poor in the cake, and yet one which does not consume so much time in use as to make it impracticable. The scoring should reflect principally what the consumer wants in a cake.

The following scoring, for a cake alone and for the icing alone, is aimed to meet the requirements of those who are concerned with keeping useful records on cakes intended to be bought and eaten.

The Cake without Icing

Eye appeal—general appearance	*Points*
Volume	10
Contour, shape, and color	7
Bottom color and condition	3
Grain	
Evenly distributed cells without open tunnels or streaks	15
Texture	
Moist, tender crumb	25
Flavor and eating quality	
A pleasing flavor	20
Over-all good eating quality	20
Total	100

The Icing on a Frosted Cake

Eye appeal—appearance, color, and sheen	40
Eating quality—flavor and smoothness	60
Total	100

It will be noted that the 100 points for the cake without icing are divided 20 for eye appeal, 15 for grain, 25 for texture, 20 for flavor, and 20 for eating quality. Probably no two scorers would agree exactly on this distribution of points, but the great majority of scorers consulted feel that this type of breakdown is substantially sound. Practical use of this system has demonstrated that different scorers agree closely, not only on the total score of the cake, but also on their appraisal of the principal good points and poor points.

Eye Appeal—General Appearance.—The visual acceptability of the cake is important. The appearance of the cake will reveal whether or not the formula is well balanced, whether the proper amount of batter was placed in the particular size of pan used, whether the cake was baked at the correct temperature and for the required length of time, and whether or not other production problems were handled carefully. The volume, contour, shape, top and side color, bottom color, and condition—all influence the degree of acceptance.

Grain.—The surface of the cut cake should show evenly distributed cell walls without open tunnels or streaks and a degree of fineness of grain dependent upon the type of cake being scored.

Texture.—The crumb should be moist and tender, consistent with the type of cake. Texture of cake is very important. It is judged by itself but also appears indirectly as a factor in "eating quality," and to a moderate extent in the appearance of the "grain."

Flavor and Eating Quality.—The flavor in a cake must be neither faint nor harsh, but of a delicate nature complementary to the type of the cake. The flavor must be so clear that it will truly designate the particular flavor wanted. Only enough flavor or blend of flavors, whether natural or artificial, should be used to bring out a pleasing quantity of taste and aroma. It is a well-known fact that chefs invariably season all foods delicately. It is left to the discretion of the individual gourmet to satisfy any desire for more pronounced strength of flavor by seasoning his food with salt, pepper, or other seasonings at the table. Unfortunately, cakes are not handled by chefs and cannot be flavored to meet all individual tastes at the time they are eaten. Therefore, the finished cake should have a pleasing aromatic flavor that will appeal directly to the great majority of consumers.

Consumers pay much attention to eating quality, which involves lightness without doughiness or crumbiness.

There may be a measure of chewiness to sponge cake and angel cake, for instance, but tender shortness is required in pound cakes.

The Icing.—The scoring of the icing on the frosted cake may be highly detailed. For practical everyday purposes, however, the main considerations are visual attractiveness of the icing and its eating quality, as indicated under the headings listed.

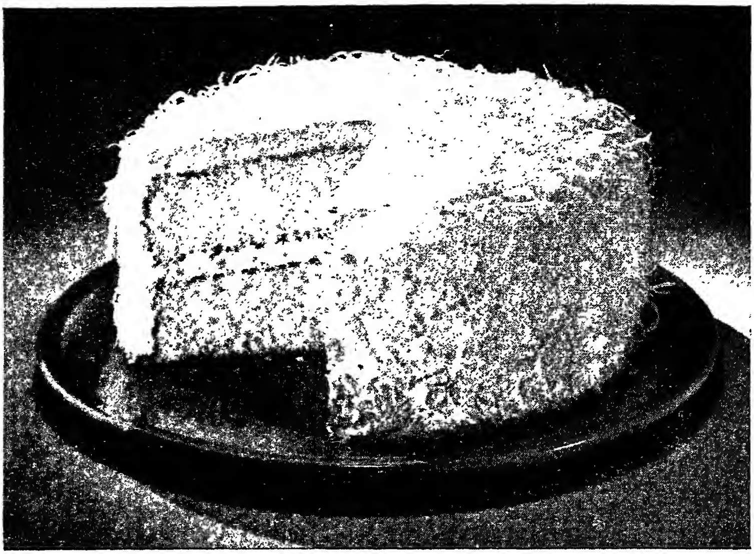


FIG. 33.—Eye appeal. (*Courtesy of Lever Brothers Company.*)

General Observations on the Scoring of Cakes.—Cakes should be scored before being finished, that is, iced, because the finishing or garnishing of cakes can readily cover up inferior qualities. A cake that has been overbaked, flavored with crude synthetic flavors, colored with gaudy artificial coloring, or made from an improperly balanced formula or poor-quality ingredients, may be given good eye appeal simply by covering the inferior qualities in the cake with a smooth, delicately colored icing, artistically applied.

Cake scoring should be done in an atmosphere that is comparable with that enjoyed by the consumer. They should be judged and scored outside of the manufacturing establishment, because odors in the plant may interfere with smelling and tasting by the tester and vitiate his judgment. Cakes should not be scored when warm. If cakes, plain or iced, are to be sold wrapped, or boxed, and to be eaten when twenty-four or forty-eight hours old, they should be scored and judged on that basis rather than when one hour old. One should avoid having a new cake judged by the sales manager or any other one person on the basis of his likes and dislikes, and in a setting that in no way resembles the actual conditions under which the product will be judged by the consumer.

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